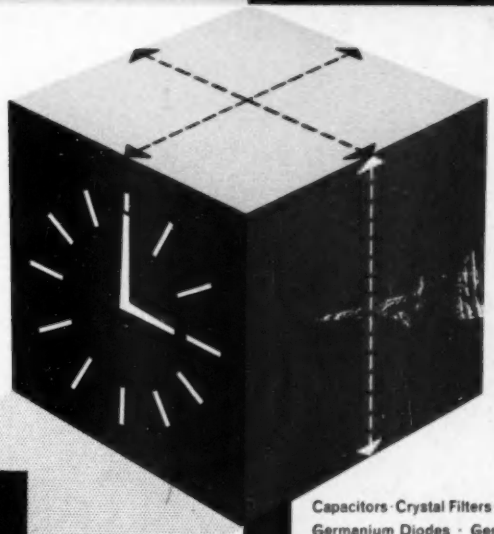
Electronic Engineering

STC

and the fourth dimension —



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Heater Voltage (volts)	V_h	6.3
Heater Current (amps)	I_h	0.3

TENTATIVE RATINGS AND DATA

Maximum Design Centre Ratings

Anode Dissipation (watts)	$p_{a\ (max)}$	2.5*
Screen Dissipation (watts)	$p_{g2\ (max)}$	0.8*
Anode Voltage (volts)	$V_{a\ (max)}$	250
Screen Voltage (volts)	$V_{g2\ (max)}$	250
Heater to Cathode Voltage (volts rms)	$V_{h\text{-}k\ (max)\ rms}$	150†
Control Grid to Cathode Resistance (megohms)	$R_{g1\text{-}k\ (max)}$	0.6‡

*With grid to cathode resistance not exceeding 10 kΩ.
†From cathode to higher potential heater pin.
‡With $p_{a\ (max)} = 2$ W; $p_{g2\ (max)} = 0.5$ W; and assuming a common anode and screen decoupling resistance. $\lessdot$ 2.2 k Ω ± 10%.

Inter-Electrode Capacitances (pF)§

Input Capacitance	c_i	8.8
Output Capacitance	c_{out}	2.6
Grid 1 to Anode	$c_{g1\text{-}a}$	0.006
Grid 1 to Grid 3	$c_{g1\text{-}g3}$	0.1
Grid 1 to Grid 2	$c_{g1\text{-}g2}$	2.0
Grid 1 to Cathode	$c_{g1\text{-}k}$	6.2
Grid 2 to Anode	$c_{g2\text{-}a}$	0.15
Grid 3 to Anode	$c_{g3\text{-}a}$	0.47

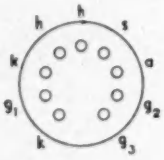
§Measured in fully shielded socket, without can.

TYPICAL OPERATION

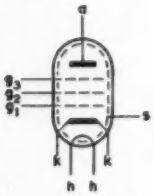
Anode Voltage (volts)	V_a	170
Screen Voltage (volts)	V_{g2}	170
Self Bias Resistance (ohms)	R_k	150
Anode Current (mA)	I_a	10
Screen Current (mA)	I_{g2}	2.7
Mutual Conductance (mA/V)	g_m	15
Inner Amplification Factor (g_1 to g_2)	$\mu_{g1\text{-}g2}$	65
Equivalent Grid Noise Resistance (ohms)	R_{eq}	370
Input Loss at 38 Mc/s (Pins 1 and 3 strapped) (kΩ)	$r_{g1\text{-}k\ (w)}$	8.5
Working Input Capacity** measured at 38 Mc/s (pF)	$c_{in\ (w)}$	13.7
Change in Input Capacity produced by biasing valve to cut-off, measured at 38 Mc/s (pF)	$\Delta c_{in\ (w)}$	3.4
Figure of Merit†† (Valve only) (Mc/s)		375
Effective Figure of Merit (Valve and Circuit) (Mc/s)		220

**Inter-electrode capacity with holder capacity balanced out.
††Given by $\frac{g_m \times 10^3}{2\pi\sqrt{c_{in\ (w)}\ c_{out}}}$ see "Aspects of Design" No. 1 for further details (Wireless World July 1958).

Base: B9A (Noval) **Mounting Position:** Unrestricted



VIEW OF FREE END



Maximum Dimensions (mm)

Overall Length	56
Seated Height	49
Diameter	22·2

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Radio and Electronic Components Division
Technical Service Department
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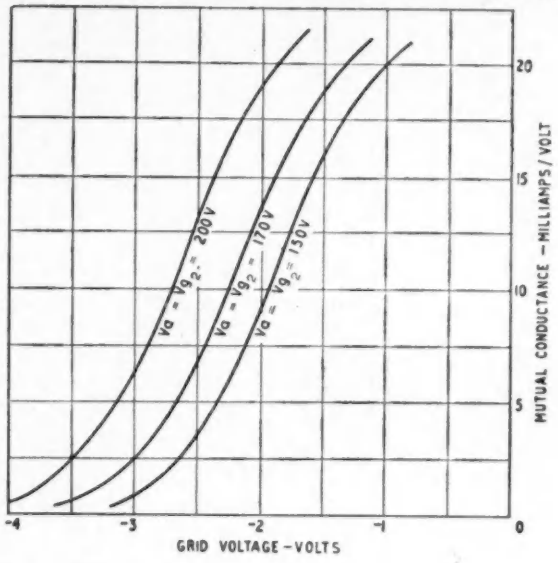
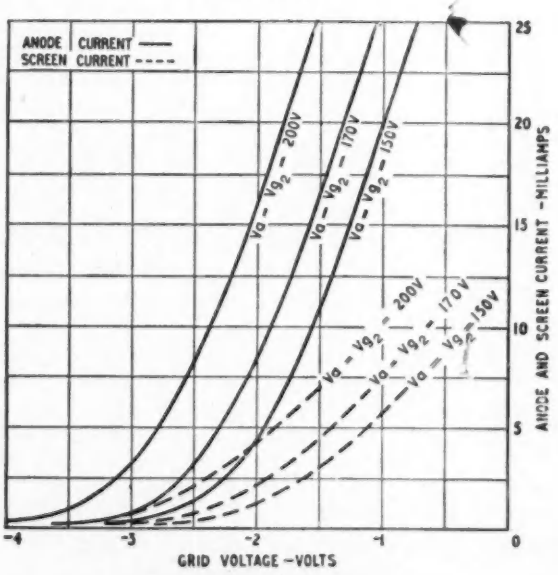
Tentative Characteristic Curves of Ediswan Mazda Valve Type 6F24





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Vol. 33 No. 397

MARCH 1961

Electronic Engineering

Incorporating ELECTRONICS, TELEVISION and SHORT WAVE WORLD

Managing Editor: H. G. FOSTER, *M.Sc., M.I.E.E., M.Brit.I.R.E.*

CONTENTS

	Commentary	137
	Cold-Cathode Tube Circuits for Automation (Part 1) *by R. S. Sidorowicz*	138
	A High Speed Analogue to Digital Convertor *by N. Winterbottom and J. S. B. Walters*	144
	A Novel Digital Clock *by A. Russell*	150
	A Versatile Forcing Function Generator *by J. Morrison*	155
	The Measurement of Flow Velocities	159
	A Satellite Tracking Station in Britain	160
	A Design Chart for Aerials with Parabolic Reflectors *by C. O. Titley*	162
	The Commonwealth Trans-Pacific Telephone Cable	163
	A 500ft Aerial Tower for London	163
	Electroluminescence—Its Characteristics and Applications (Part 2) *by D. H. Smith*	164
	Band-pass Ladder Filters Employing Ceramic Resonators *by R. C. V. Macario*	171
	Letters to the Editor	178
	Book Reviews	180
	Short News Items	182
	Electronic Equipment at the Physical Society Exhibition	184
	Meetings this Month	190
	Publications Received	190
FRANÇAIS	Le Matériel Électronique au Salon de la Physical Society	191
	Résumés des Principaux Articles	196
DEUTSCH	Elektronische Geräte auf der Ausstellung der Physical Society	198
	Zusammenfassung der wichtigsten Beiträge	203

CLASSIFIED ADVERTISEMENTS page 196 INDEX TO ADVERTISERS page 207

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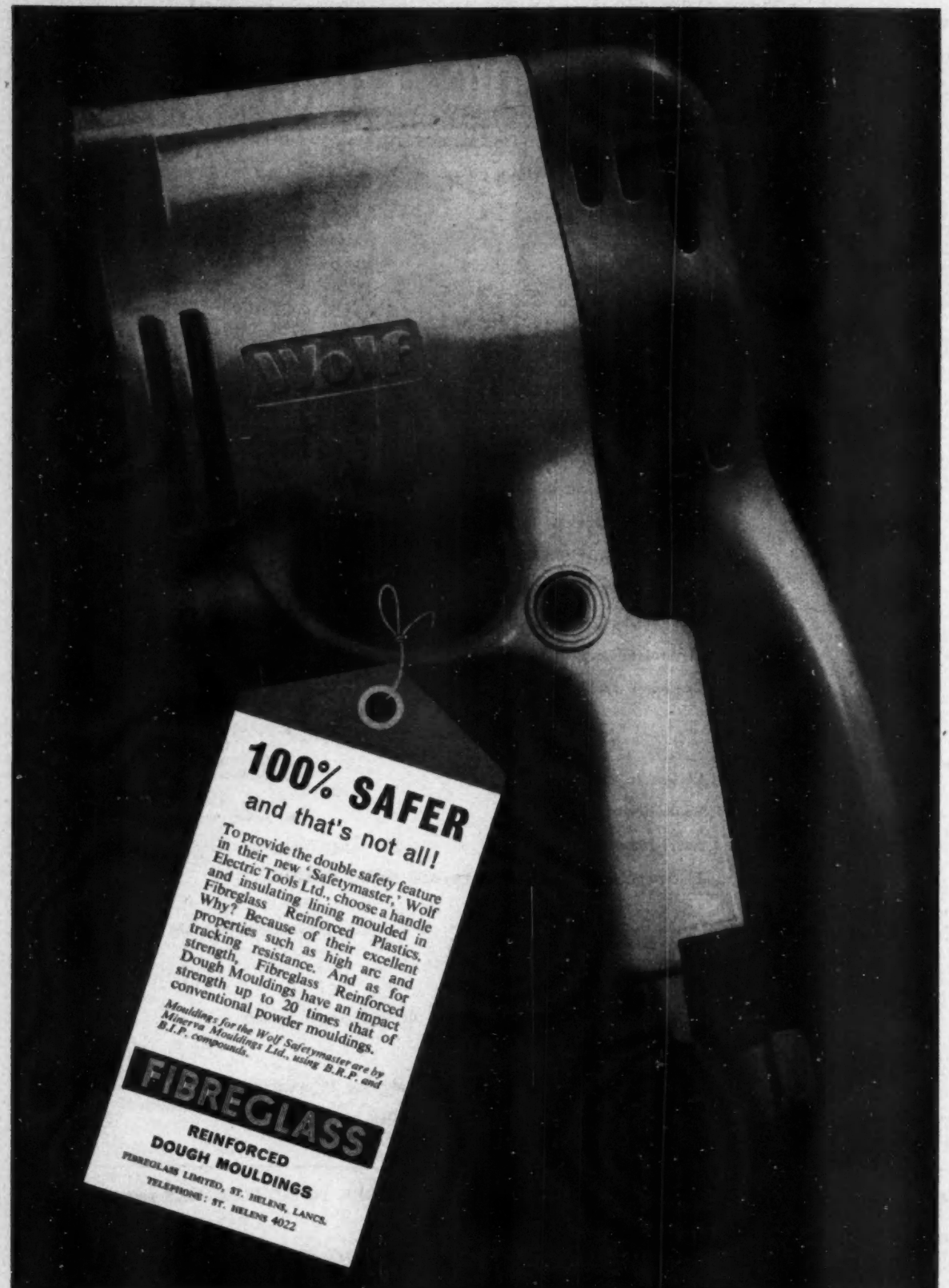
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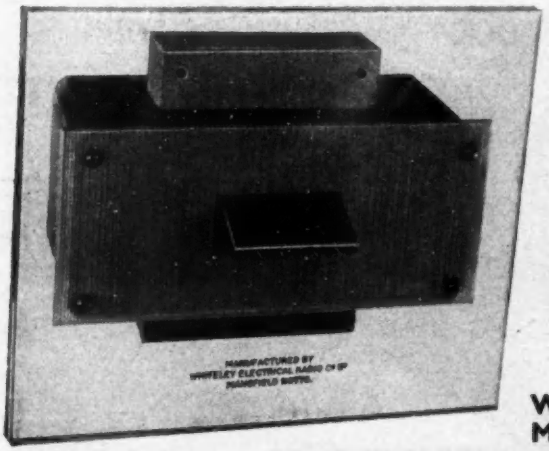

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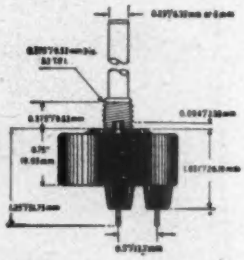

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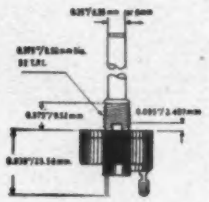

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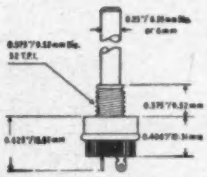

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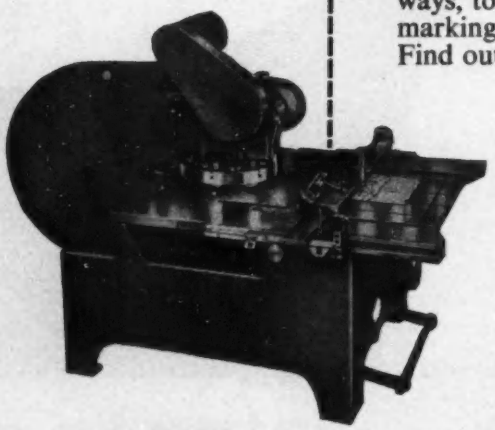

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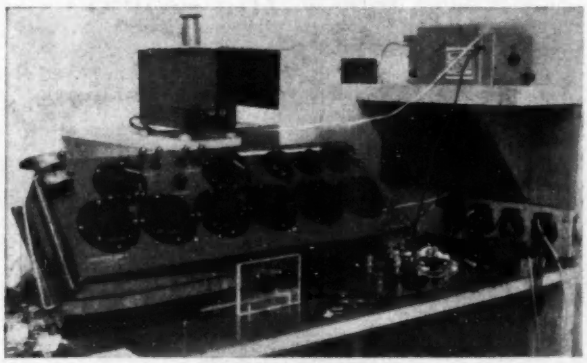

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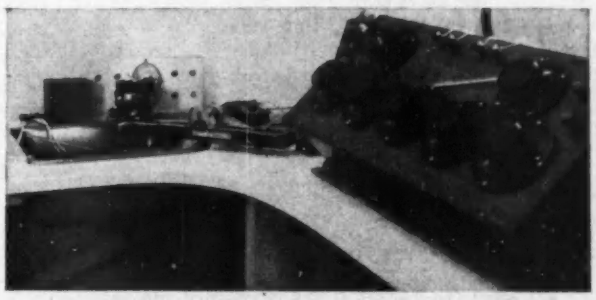

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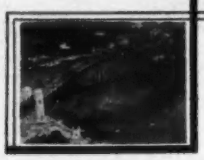

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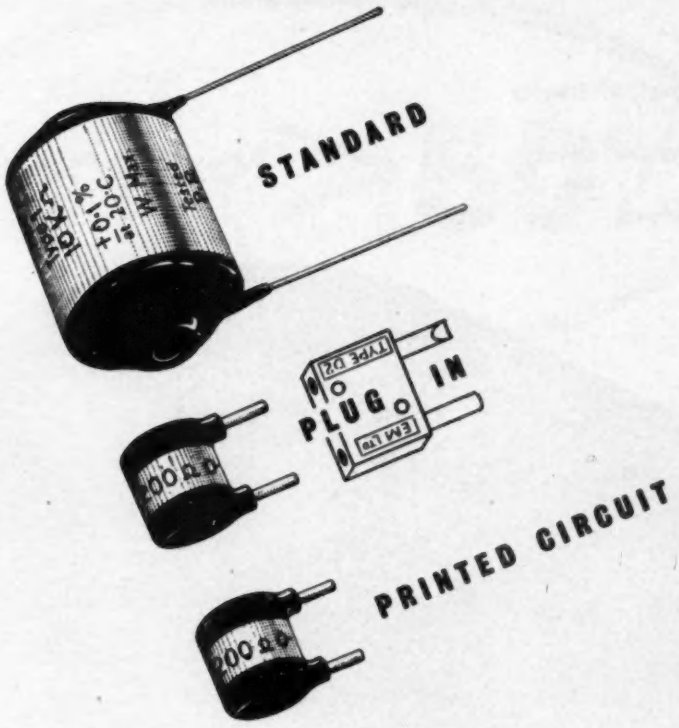

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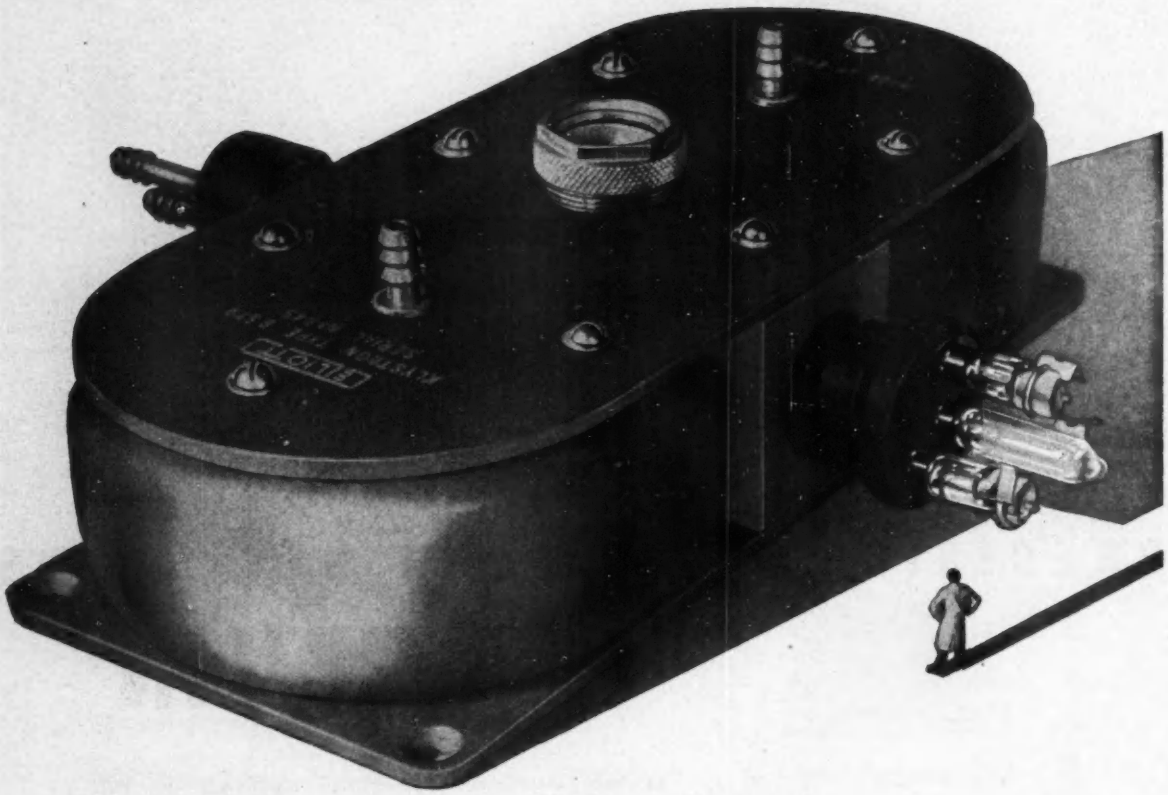

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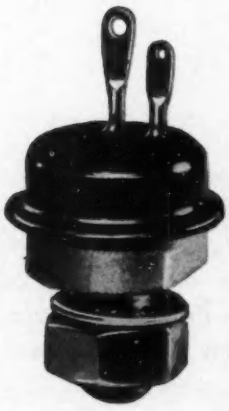

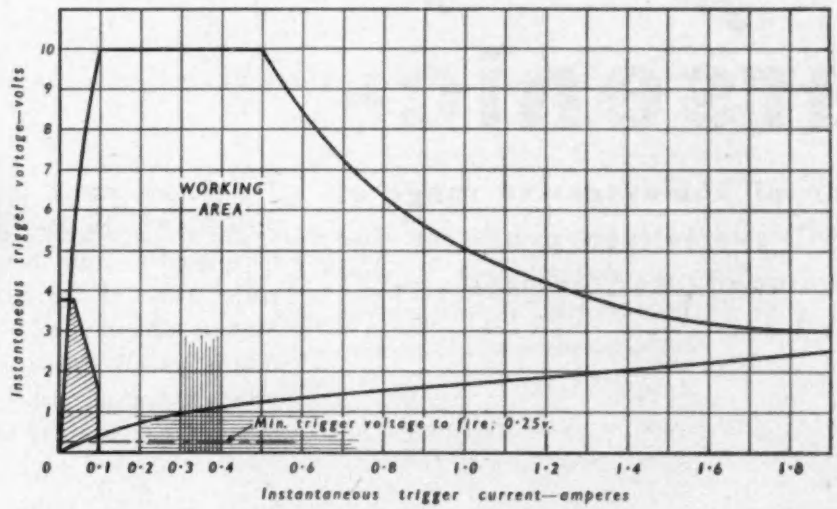

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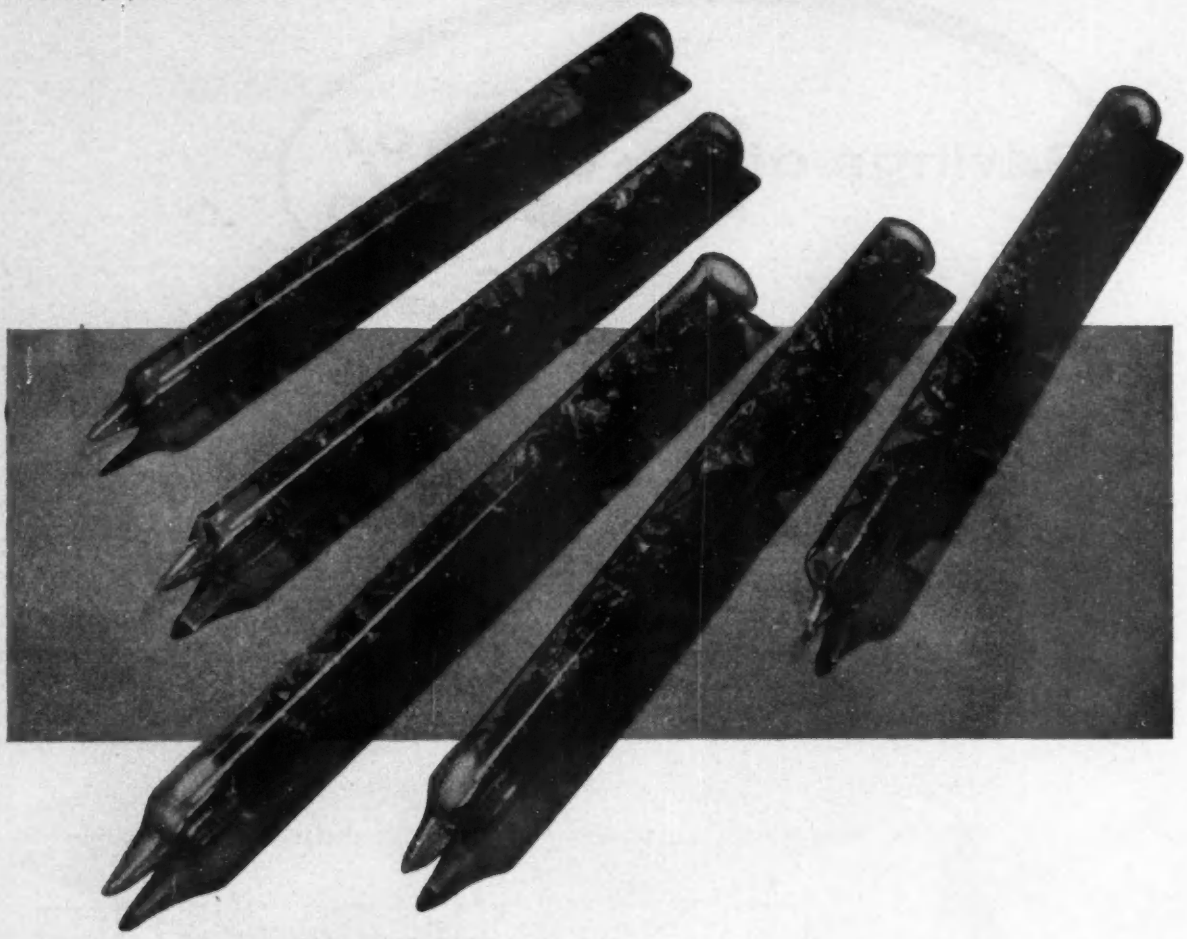

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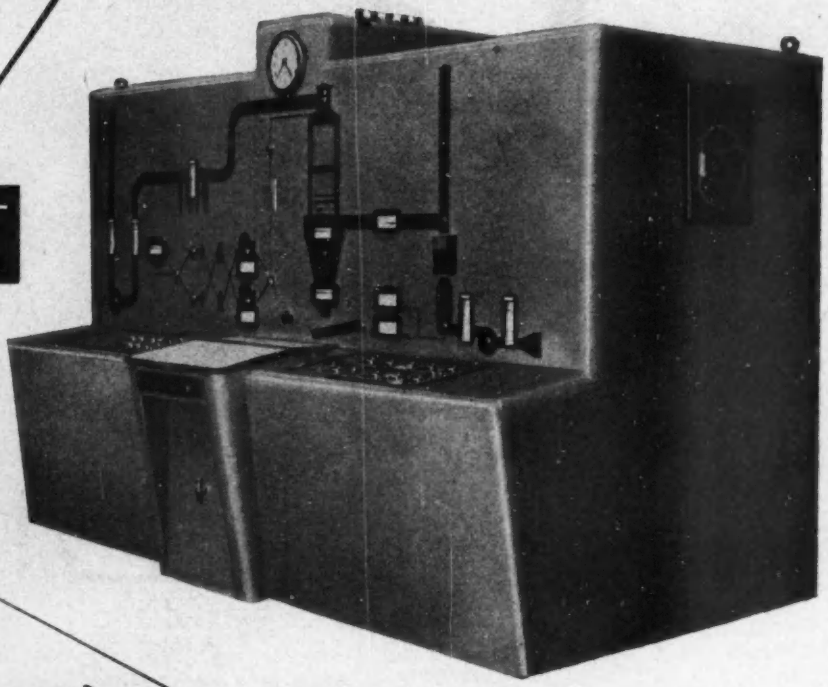

CONTROL desks and panels

Lintott offer a complete service for the fabrication, finishing *and* electrical assembly of all forms of control gear in the electronics and nuclear energy fields. Lintott constructions are in use for a wide variety of process controlling, fuel control, burner control, etc. They can be finished for interior or exterior use, pressurized, and in desk, panel or cubicle form.

LIN-CABINET chassis racks

A specialised Lintott construction providing a completely flexible system for housing electronic and electro-mechanical equipment. Each unit is self-contained, with built-in cooling or heating facilities, and are suitable for slight pressurization. Standard drawers of 8", 12" and 16" depth can be used in any combination to give a total height of 52". Lin-cabinets are K114 approved for the three Services. Write for full details.

LINTOTT engineering ltd.

AYLING INDUSTRIES GROUP

Horsham, Sussex. Telephone: Horsham 3316

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"Twitterton!

Is this really

FORMICA*?"

Yes, this is a printed circuit made from FORMICA COPPER-CLAD material. It is a vital part of the new Industrial Analogue-Digital Converter made by Ericsson Telephones Limited. The printed circuit helps to lower the cost of this instrument, and ensures that maintenance will be little and easy. FORMICA copper-clad laminate was considered dependable enough for this important job in the field of electronics.

People (including Twitterton's friend, and perhaps even you) are finding it difficult to keep up with all the things Formica Limited are doing nowadays. Which isn't surprising. You've got to be pretty quick to keep pace with a fast-moving company like this!

FORMICA make

EXTRUDED PLASTICS
DECORATIVE LAMINATES
CHAIR SETS
INDUSTRIAL LAMINATES

For full information on any FORMICA product please write to :
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* FORMICA *is a registered trade mark*

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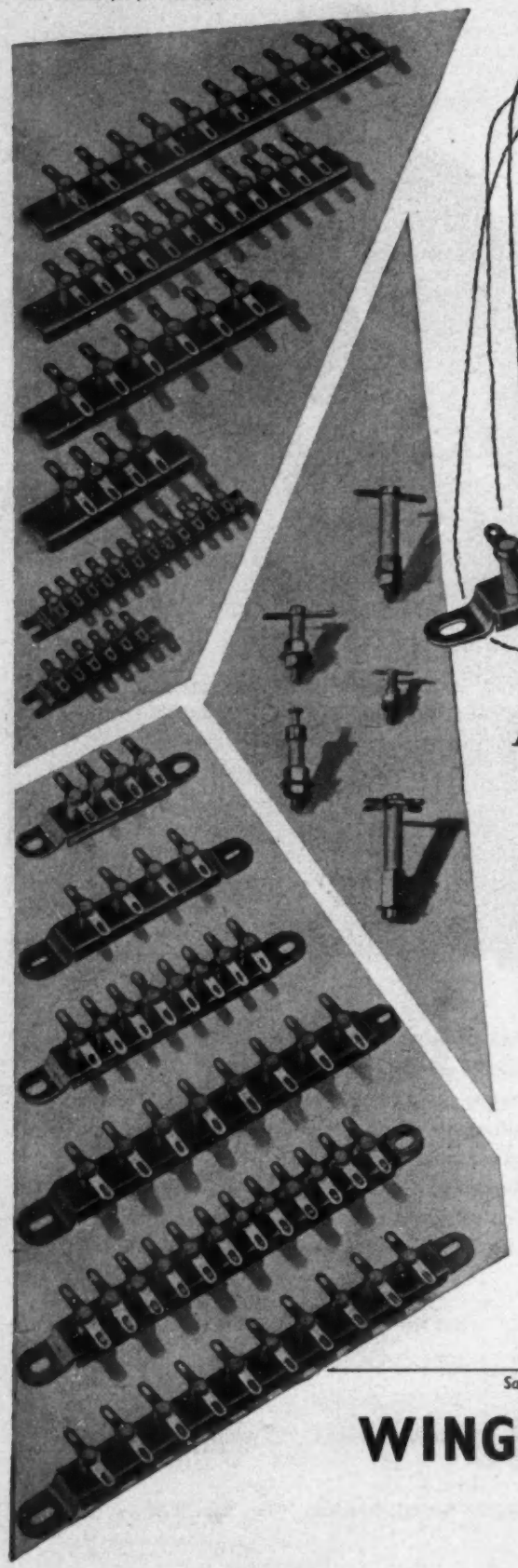
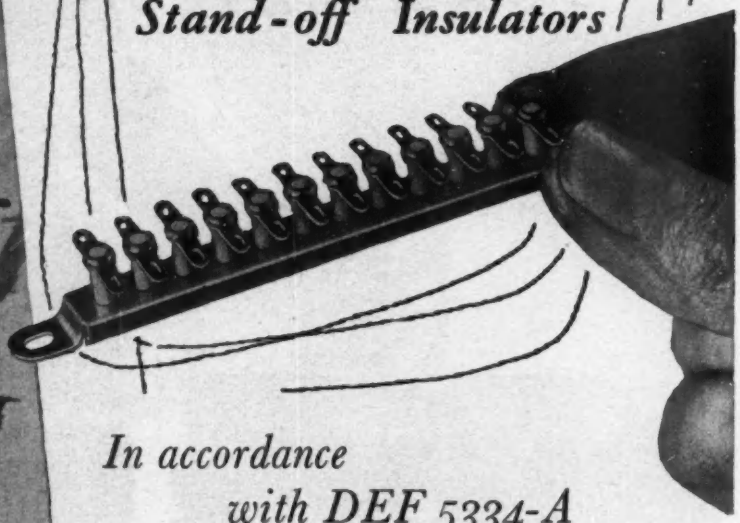


POLAR

Terminal Strips and Stand-off Insulators



In accordance with DEF 5334-A

Suitable for all forms of assembly, these high efficiency inexpensive Terminal Strips and Stand-off Insulators are available in a wide range of sizes.

The Stand Off Insulators are mounted by means of Screwed Stems or Tapped holes. Connections may take the form of Tags, Spills or Screwed Stems.

Terminal Strips in Cadmium plated steel with pillars of sintered aluminium oxide, are available in several types with $\frac{5}{32}$" $\frac{1}{4}$" or $\frac{3}{8}$" spacing between terminals. Insulation resistance better than 10,000 megohms.

Polar

Samples and Prices on application to Department 'C'

WINGROVE & ROGERS LTD.

HEAD OFFICE: Domville Road, Old Swan, Liverpool, 13.
Phone: Stoneycroft 2265 Grams & Cables: Components Liverpool
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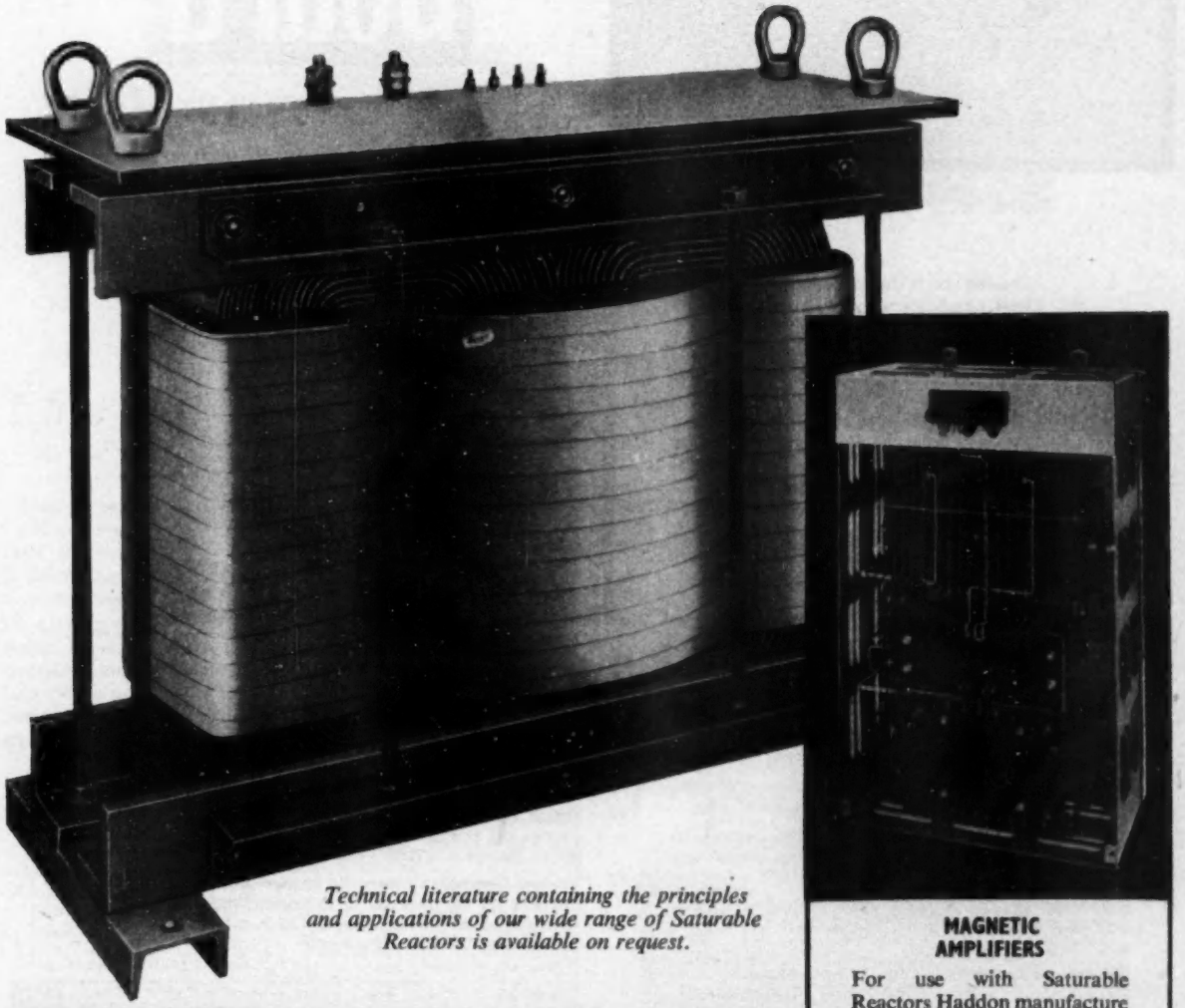
HADDON

STANDARD
SATURABLE REACTORS
TRANSDUCTORS

Haddon **"STANDARD"** Saturable Reactors—Transductors operate from conventional A.C. line Voltages and provide a choice of D.C. Voltages for Control Windings. Selected from a wide range of individually designed and manufactured **SPECIALS** over past years, the **HADDON STANDARD RANGE** enable the discerning engineer to select **STANDARD EQUIPMENT** for Specific application.

416 standard single-phase designs cover the range 1 kVA to 300 kVA.

They provide the best method of stepless control in both long-term economies and high performance standard.



Technical literature containing the principles and applications of our wide range of Saturable Reactors is available on request.

MAGNETIC AMPLIFIERS

For use with Saturable Reactors Haddon manufacture a standard line of Magnetic Amplifiers.

Operating from 200/250V 50/60 c/s single-phase supply, with input of 0–5 mA DC in 2000/8000 ohms.

Illustrated above is the 1000W Magnetic Amplifier

HADDON

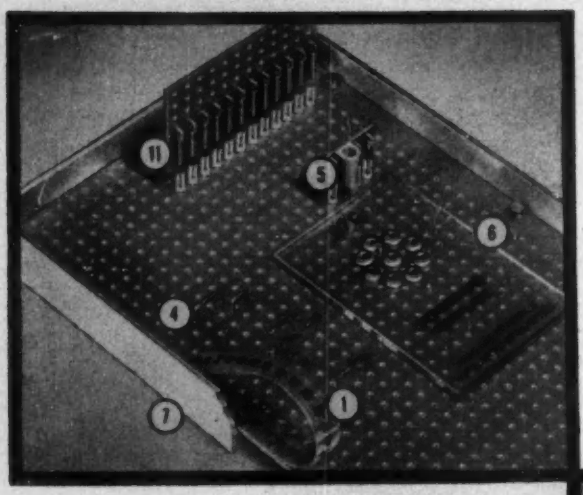
HADDON TRANSFORMERS LIMITED

Victoria Park Industrial Estate, Field End Road, Ruislip, Middx.

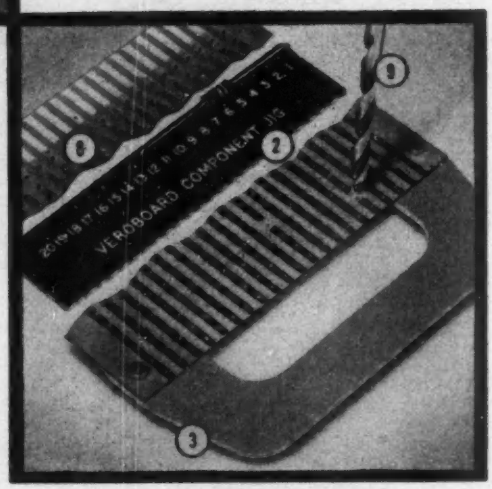
Telephone: Byron 9444-8 Telegrams: Hadtrans, Ruislip

EE 31 022 *for further details*

Fast, simple, low-cost circuit assembly



with **vero board accessories**



VEROBOARD is the universal wiring board that combines all merits of the printed circuit technique—*without the expense!* Simplicity, speed, cheapness, and reliability are the direct results of the VEROBOARD principle: standard pitching of standard-size holes on a resin-bonded laminate board backed by bonded copper continuity strips.

The following assembly aids and accessories are offered to speed and simplify the assembly of VEROBOARD circuits even further; and to provide even better service in use.

1 **Numeral tape** (self-adhesive) for fast, accurate reference to positions on VEROBOARD. 1–90 for 18″ boards and 1–30 for boards up to 6″. Part Nos. VB3021 and VB3022

2 **Component Jig** for bending wire terminations accurately to fit VEROBOARD matrix. Part No. VB 3031

3 **Plastic Handles** for plug-in VEROBOARD card circuits. Part Nos. VB3051 (black) and VB3052 (red)

4 **Jumper Links** of tinned copper wire for cross connections between bonded copper backing strips on VEROBOARD. Part Nos. VB3061 (0·2″) and VB3062 (0·4″)

5 **Semiconductor Holders** for mounting transistors, etc. with plug-in contacts on 0·2″ matrix. Part No. VB2011 and VB2012

6 **Valveholder Templates** for drilling holes at correct pitch and location on VEROBOARD. Part Nos. VB3041, VB3042 and VB3043

7 **Extruded Edging** in light alloy for strengthening VEROBOARD panels. Part No. VB3091

8 **Plug-in Panels**: 4·8″ × 5·8″ VEROBOARD, gold-plated at one end for use with edge connectors. Part No. VB2001

9 **Spotface Cutter** to make a clean separation where necessary in copper backing strip. Part No. VB3011

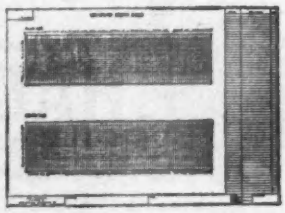
10 **Design Sheets** on high quality tracing paper for designing circuits on VEROBOARD and for producing workshop prints. Part Nos. VB3071 (18″) and VB3072 (6″)

11 **Varicon Connectors** which can be used as single point contacts or in rows to form connections between VEROBOARDS. Available in strips of 20. Part No. VB3081 (in line and VB3082 (right angle).

vero board

Notching Tool for Extruded Edging to enable it to be mitred for making corners and for slotting to take VEROBOARD panels. Part Nos. VB3101 Press, VB3102 Mitre die set, VB3103 Slotting die set.

VEROBOARD Kit contains supply of VEROBOARD and accessories.



(10)

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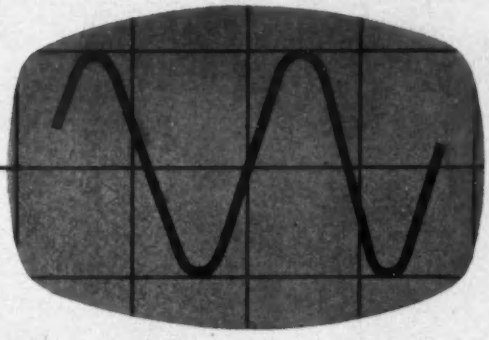
STABILIZED SINUSOIDAL VOLTAGE



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the CVH RANGE

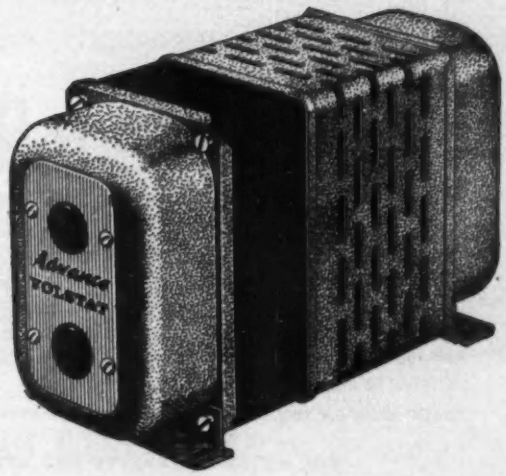
VOLSTAT

Advance constant voltage transformers are available in the CVH range with low harmonic distortion in the output waveform, ideal for use with precision equipment sensitive to power frequency harmonics, and also with all equipment requiring a constant voltage sinusoidal input.

In most applications the harmonic distortion present in the output waveform will not exceed 3%. Under the most unfavourable conditions this figure will not rise substantially above 5%. When used with a rectifier to provide a d.c. supply, the characteristics of the system are identical to the normal mains source and particularly close regulation of the output is obtained.

- CONTINUOUS AND AUTOMATIC STABILIZATION
- RAPID RESPONSE TIME
- CURRENT LIMITING CHARACTERISTIC
- COMPACT DESIGN
- NO MOVING PARTS
- NO ROUTINE MAINTENANCE

Type	I/P V Range	O/P V r.m.s.	Watts	p.f.	Nett Price in U.K.
CVH 60A	190–260 50~	240	60	1·00	£10 10 0
CVH 125A	190–260 50~	230	125	1·00	£17 0 0
CVH 420A	190–260 50~	230	420	1·00	£37 0 0
CVH 750A	190–260 50~	230	750	1·00	£68 0 0
CVH 1500A	190–260 50~	230	1500	1·00	£99 0 0
CVH 3000A	190–260 50~	230	3000	1·00	£185 0 0
CVH 6000A	190–260 50~	230	6000	1·00	£355 0 0



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MAINS STABILIZATION DIVISION

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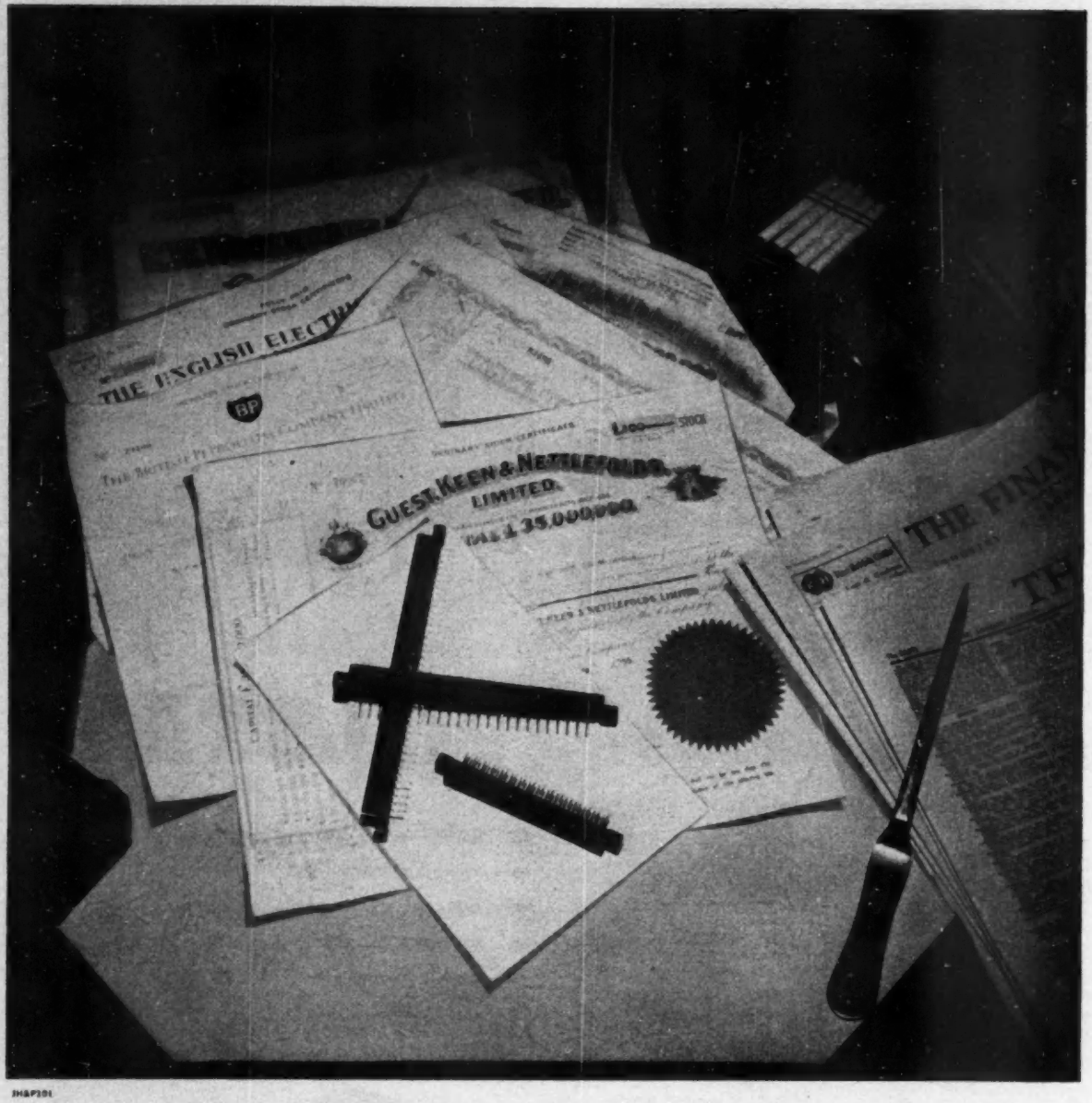

JH&P101

How to make a Gilt-edged Investment

Ordering printed wiring edge connectors should be regarded as making an investment. Your investment can be gilt-edged if you specify CONTINENTAL—CONTINENTAL can offer you a wider range of printed wiring connectors than any other manufacturer and this range includes the new international standards. All are gold plated but can be offered in many variants to suit your particular application

Please write for leaflets, outlining your requirements

PRINTED WIRING CONNECTORS

SINGLE-SIDED BOARDS			DOUBLE-SIDED BOARDS		
Contact pitch	*Board thickness*	*Number of ways*	*Contact pitch*	*Board thickness*	*Number of ways*
0.100	0.062	8, 16, 24 & 32	0.150	0.062	16, 32, 48, 64 & 80
0.150	0.062	8, 16, 24, 32 & 40	0.200	0.062	16, 32, 48 & 64
0.156	0.062	6, 10, 12, 15, 18, 22 & 27	0.200	0.093	48 & 56
0.200	0.062	4, 8, 12 & 16	*Many other types are available*		
		(0.100 with alternate contact omitted)	SPECIAL DESIGN		
			0.150	0.062	10&32 single-sided & 20 double-sided
0.200	0.062	8, 19, 24 & 32			
0.200	0.093	24 & 28	0.156	0.062	36 ways double

ALSO AVAILABLE

Miniature plug & socket connectors. Sub-miniature rectangular plug & socket connectors. Micro-miniature rectangular plug & socket connectors. Hermetic-sealed miniature plugs. Taper-pin terminal blocks

FOR BUILT-IN QUALITY AND RELIABILITY, SPECIFY Continental Connectors

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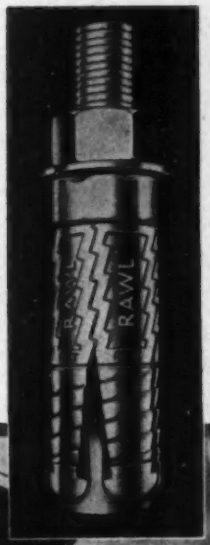
rock-firm fixing in fractional times with RAWLBOLTS



Rawlbolts have revolutionized bolt fixing. A job that once took days is now done in minutes—no cold chiselling, no waiting for cement to harden, no mess! Rawlbolts reduce bolt-fixing to three swift and simple operations—drill the material, insert the Rawlbolt, tighten up. The fixing is ready to take its full load *at once*, because a Rawlbolt is a dry fixing that grips by expansion. Rawlbolts are used by the million by all the great industries of the world, and everywhere their record is the same—completely safe, reliable fixings of enormous strength in only a fraction of the time taken by out-dated methods.

A RANGE FOR EVERY NEED —AND EVERY MATERIAL

The Rawlbolt is one of the 21 different types of Rawlplug Fixing Devices that speed up and simplify every kind of screw or bolt fixing job in hard materials. Other devices include the famous Rawlplug—vastly quicker and easier than any other method of screw-fixing; White Bronze Plugs for high temperatures and under-water fixtures; the amazing Rawlnut for hollow materials which forms its own 'rivet-head' behind the material, airtight, watertight and vibration-proof, and Spring and Gravity Toggles for plasterboard and similar structurally weak materials. Write now for full details of these time-and-money saving devices.

The Gratacielo di Milano—reputed the highest skyscraper in the world constructed entirely of reinforced concrete. Rawlplug Fixing Devices were used extensively throughout this building. These Devices ensure complete safety in fixing Lighting, Heating, Ventilating, Sanitary and other fittings, and are suitable for every material from sheet metal, and plastic partitions to fixings in concrete ceilings.

RAWLBOLTS

FOR SPEED AND STRENGTH

THE RAWLPLUG COMPANY LTD · CROMWELL ROAD · LONDON · S.W.7

B674

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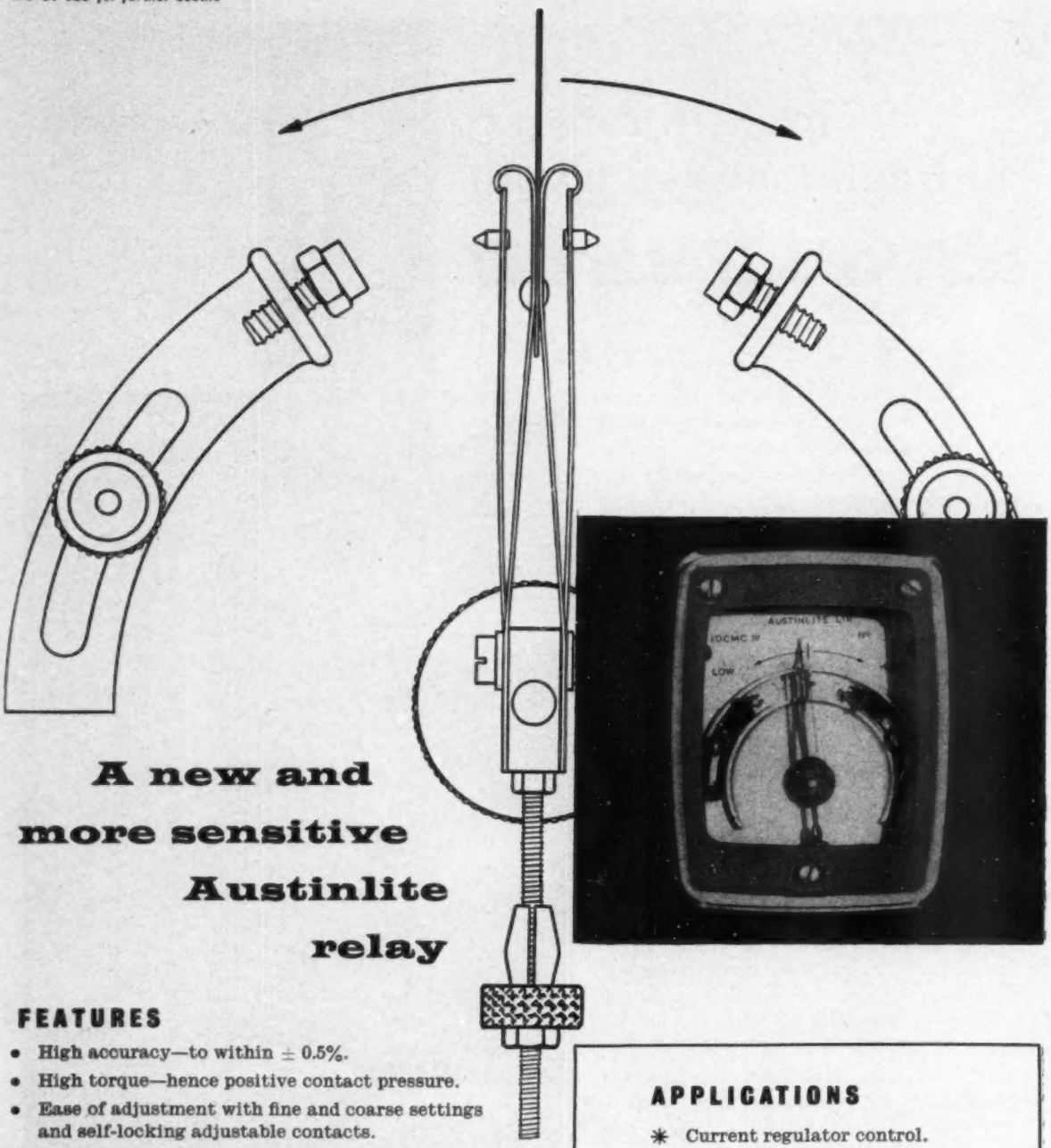


A new and more sensitive Austinlite relay

FEATURES

- High accuracy—to within ± 0.5%.
- High torque—hence positive contact pressure.
- Ease of adjustment with fine and coarse settings and self-locking adjustable contacts.
- Choice of either two or four adjustable contacts.
- Contemporary case design—projection or flush mounting.
- Dustproof and suitable for use in the tropics.
- Conforms to Post Office Specification P.T. 1025B.
- Suitable for current or voltage sensing on either D.C. or A.C.

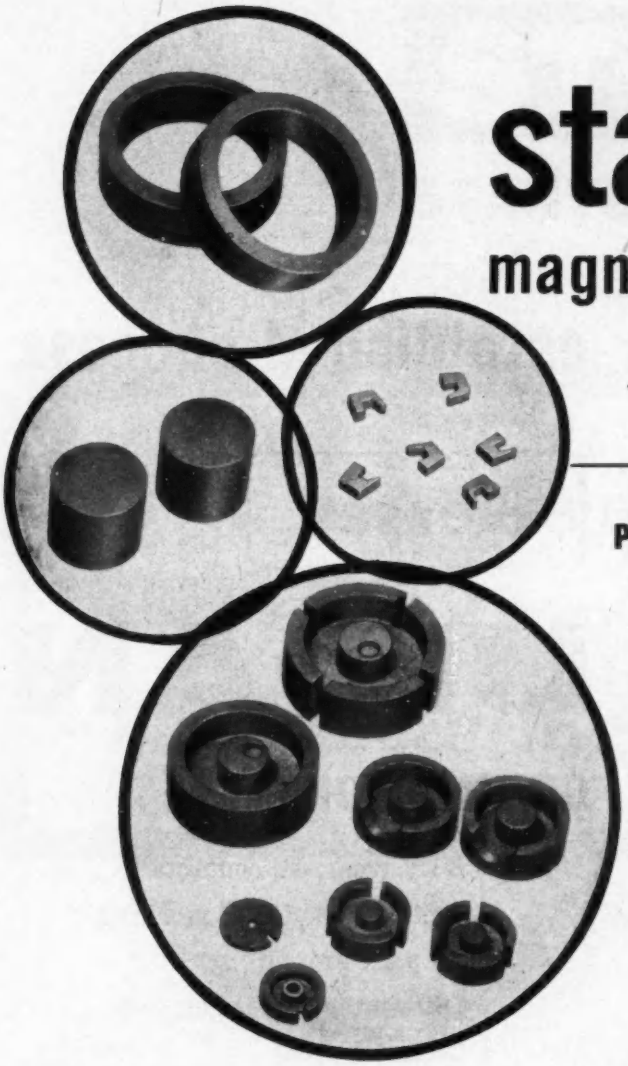
APPLICATIONS

- Current regulator control.
- Voltage regulator control.
- Monitoring duties.
- Limiting duties.
- Equipment protection.

Austinlite **ELECTRICAL EQUIPMENT**

Custom-built by STONE-CHANCE LTD.

(Makers of Sumo Pumps and Stone-Chance Lighthouses).
CRAWLEY, SUSSEX.



stanferite

magnetic materials

from STC

PERMEABILITY RANGE FROM 15 to 2500

'Stanferite' is the latest magnetic material to be added to the already well known STC range of Permalloy powder, strip and Permendur products.

'Stanferite' is a non-metallic material having high resistivity with consequent low eddy-current losses. This characteristic enables it to be used at much higher frequencies than was previously possible with metallic materials of similar permeability.

'Stanferite' can be supplied in the form of pot cores, cylinders, rings and "U"-shaped pieces to meet most applications.

Material	Initial Permeability	Frequency range of application	Typical applications	Typical Core Shapes
			(Manganese Zinc Ferrites) — both of which have high permeability and low-loss at frequencies up to 1 Mc/s.	
S.F.1	2 000 to 3 000	Up to 1 Mc/s	Wide band and Miscellaneous Types of Transformers	"U"
S.F.15	1 100 to 1 900	Up to 1 Mc/s	High quality Inductors, Communication Transformers, Delay Lines and Recording Heads.	Pot
			(Mixed Ferrites)—having substantially rectangular hysteresis loops and therefore eminently suitable for data-processing applications.	
S.F.3	100	Pulse		Small Toroid and Magnetic Cell
S.F.11		"	Memory Arrays and Switching for Data Processing.	
S.F.14		"		
			(Nickel Zinc Ferrites) — having extremely low eddy-currrant and dielectric losses rendering them useful over a very wide frequency range up to 150 Mc/s.	
S.F.4	650	50 kc/s to 2 Mc/s		
S.F.5	250	200 kc/s to 5 Mc/s		
S.F.6	100	500 kc/s to 15 Mc/s	H.F. Transformers and Inductors, Tuning Coils, Saturable Reactors.	Toroid, "U" Pot and Cylinder
S.F.7	30	1 Mc/s to 50 Mc/s		
S.F.8	15	10 Mc/s to 150 Mc/s		

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60/4MM

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Plessey

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connectors

- 2 kV r.m.s. all contacts
- −65°C to + 190°C working
- 30 p.s.i. pressure seal
- 180 contact arrangements
- Climatic proof
- Waterproof
- Shock proof
- Vibration proof
- Crimped connections
- Fireproof and hermetically sealed types
- Interchangeable with A.N. or M.S. connectors

This has prompted the publication of a fully descriptive booklet, No 109, which sets out in detail the characteristics of these outstanding connectors. Write for a copy now—on Company-headed paper; please.

Wiring and Connectors Division
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Overseas Sales Organisation:
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STC

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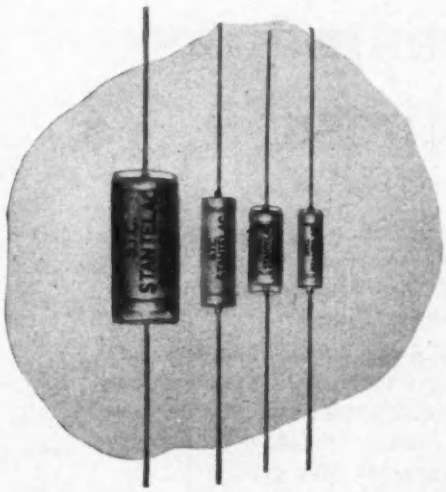
COATED FOIL CAPACITORS

a new development in Capacitor manufacturing techniques



EXCELLENT ELECTRICAL CHARACTERISTICS

HIGH STABILITY PERFORMANCE

SMALL PHYSICAL SIZE

LOW WORKING VOLTAGES FOR TRANSISTOR CIRCUITS

TEMPERATURE RANGE −40°C TO +70°C. H.I. CLIMATIC PROTECTION

CAPACITANCE RANGE 0·01μF TO 2·2μF

Send for details of the Stantelac range of capacitors and life test performance —

STC COMPONENTS GROUP

61/4MC

Standard Telephones and Cables Limited

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CAPACITOR DIVISION: BRIXHAM ROAD · PAIGNTON · DEVON

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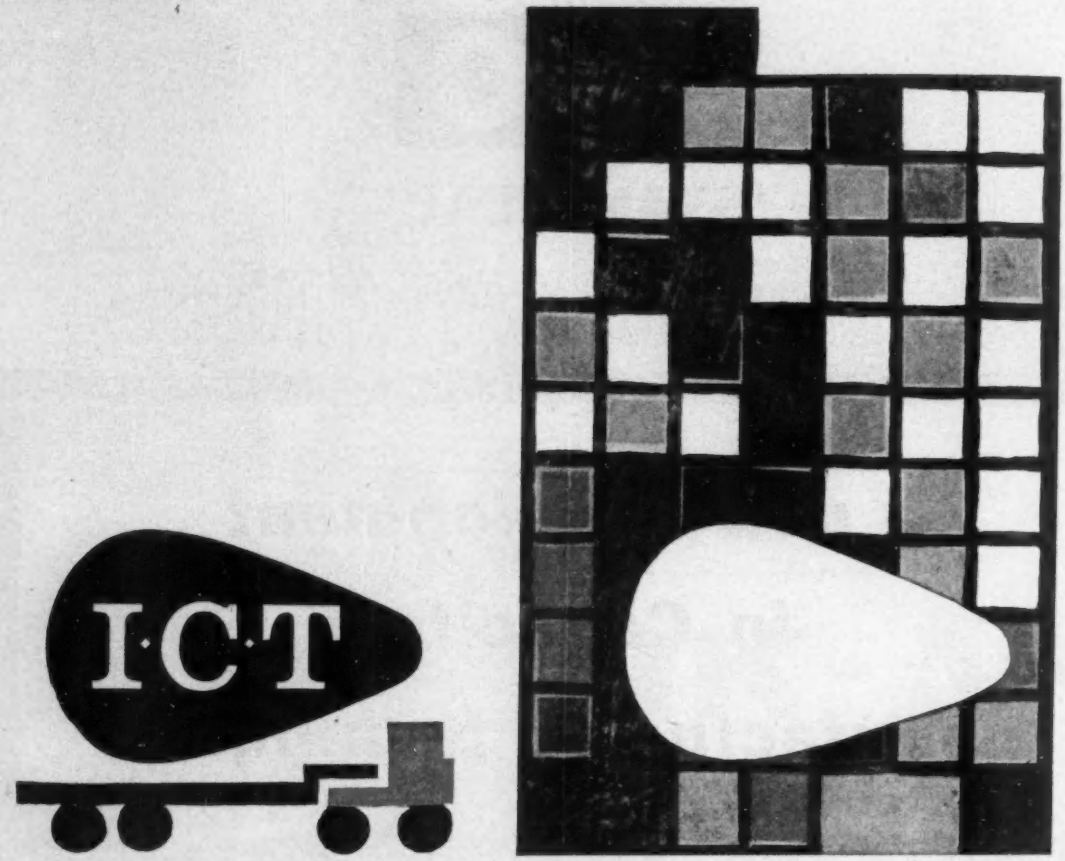

There's an I·C·T computer to fit your business

Shopping for a computer? Then you've a challenging task ahead. For this major investment must pay you major dividends.

Choosing and using a computer effectively and profitably requires imagination and great preparation. This means thinking in terms of the service you'll get as well as the machines you will use. Doing your shopping, in fact, with an organisation having the 'know-how', the resources and the experienced staff to examine your problems creatively, and to propose the data processing system that *fits into your business.*

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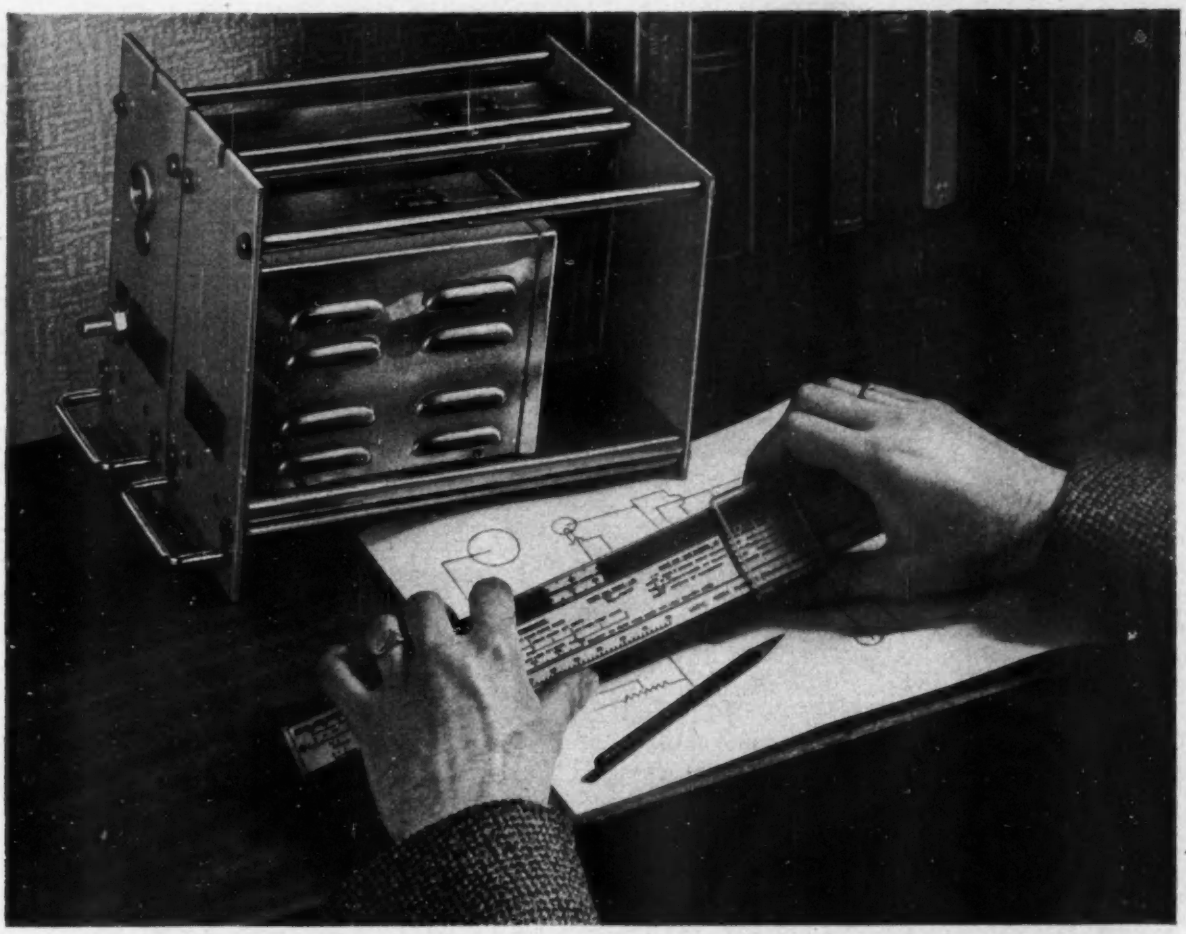
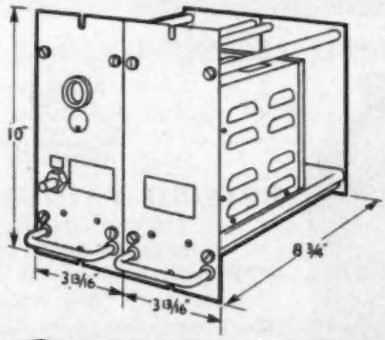


a new concept in high-stability frequency sources

The latest range of compact, high-stability frequency sources by STC represents considerable progress in size, weight and price reduction without sacrifice of ageing characteristics, short-term stability or temperature dependence.

Illustrated is the 90 LQU 802B comprising type 57 LQU 423 Quartz Crystal Unit and Temperature Control Unit Type 1LQU 101B:—



STABILITY	± 4 in 10^{10}
AGEING	1 in 10^9 per day
DIMENSIONS	Two Units 10 in. x 8½ in. x 3½ in.

Full details of all units in the range available on request from —

61/3MQ

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London W.C.2

QUARTZ CRYSTAL DIVISION · HARLOW · ESSEX

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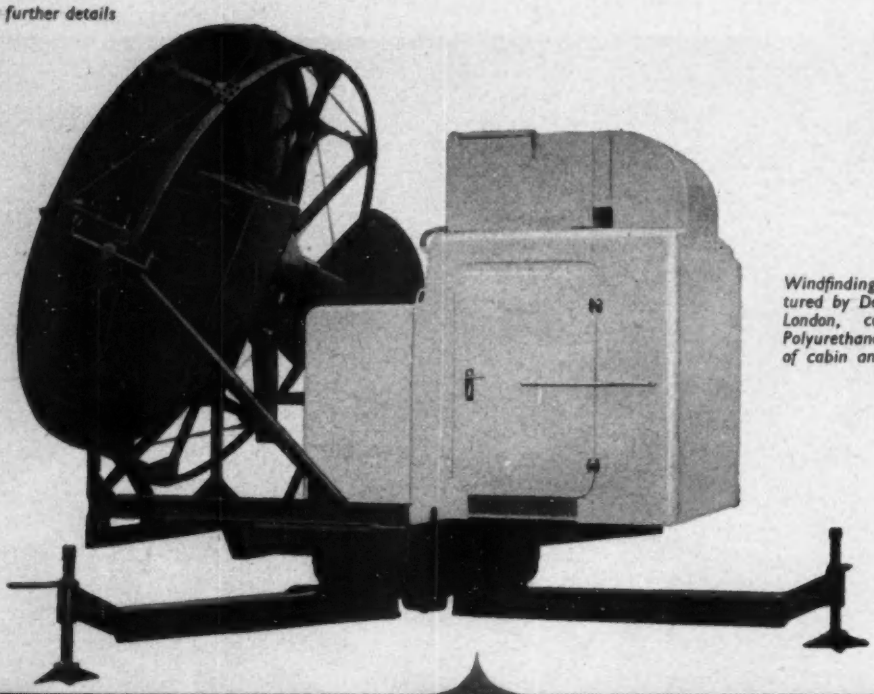

Windfinding Radar manufactured by Decca Radar Limited, London, coated with Luxol Polyurethane Enamel on exterior of cabin and chassis.

Get sales off to a good start . . .

No range of Industrial Finishes can surpass Luxol; they offer the finest finish for every industrial need. Incorporating all the latest paint developments, Luxol Industrial Finishes provide the eye appeal which influences sales. If your requirements cannot be met from our standard range we will, on request, formulate a special finish for your particular purpose. For *any* information please write to the address below

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An NEC semiconductor device for every circuit application

The range of semiconductor products at NEC is perhaps the widest of any manufacturer. Entertainment or industrial, standard broadcast frequencies to microwave — NEC has a semiconductor device with the ratings and characteristics for your application. There's a wide selection of current ratings, operating temperatures, and mountings.

These are produced in NEC's new semiconductor plant where crystal surfaces are cleaned by 100 tons of hyper pure water daily. Every seal is tested in krypton isotopes, providing a failure rate suitable for the most critical applications.

A single source for semiconductors can mean a saving in time and costs. Just let NEC know your requirements and full technical data will be sent.

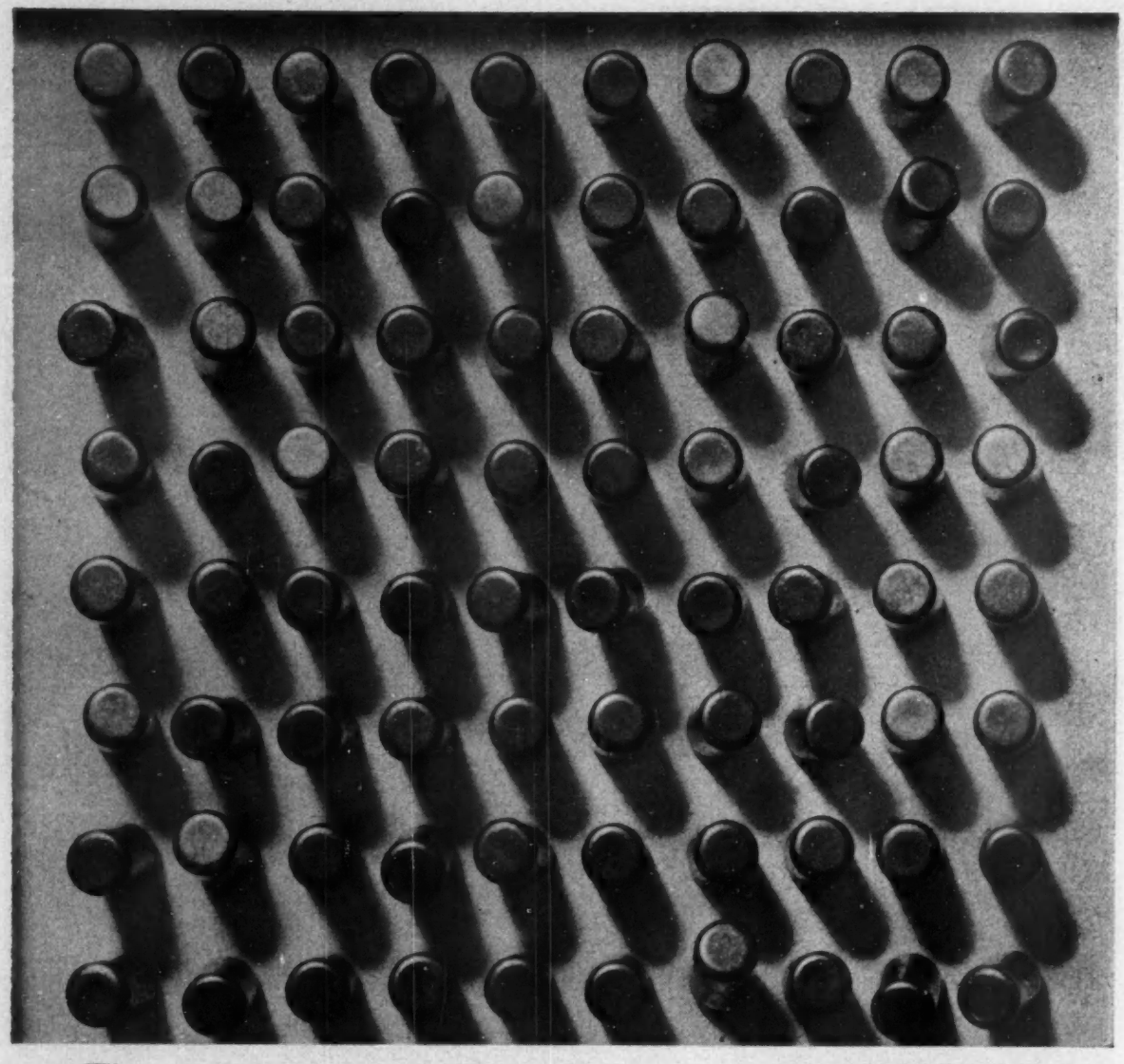
Types of NEC semiconductor devices

· PNP super-grown Germanium transistors · Germanium photo transistors · PNP alloy junction Germanium transistors · Silicon Mesa transistors · Germanium Mesa transistors · Germanium gold-bonded diodes · Silicon rectifiers · Silicon controlled rectifiers · Silicon capacitors · Zener diodes · Germanium point-contact mini-diodes · Silver-bonded diodes · Microwave mixer diodes · Silicon junction mini-diodes

Communications System / Electronic Components

NEC *Nippon Electric Co., Ltd.*

Tokyo, Japan



Germanium PNP Alloy Type TRANSISTORS

2S26	For Audio Frequency Power Amplification
2S45	For Intermediate Frequency Amplifier Service
2S52	For Converter Service
2SA49	For Intermediate Frequency Amplifier Service
2SA50	For Switching Purpose
2SA52	For Converter Service
2SA53	For Intermediate Frequency Amplifier Service
2SB26	For Audio Frequency Power Amplification
2SB47	Low Noise Factor with Audio Frequency Amplifier
2SB54	For Low Frequency Amplifier Service
2SB56	For Audio Frequency Power Amplifier Service
2SB189	For Medium Power Output Service

Germanium PNP Alloy Type DRIFT TRANSISTORS

2SA57	For High Frequency Amplifier Service
2SA58	For High Frequency Amplifier Service
2SA59	For High Frequency Amplifier Service
2SA60	For Converter Service
2SA92	For Local Oscillator Service
2SA93	For Mixer Services
2SA175	For High Frequency Amplifier Service

Toshiba

For complete information, write to

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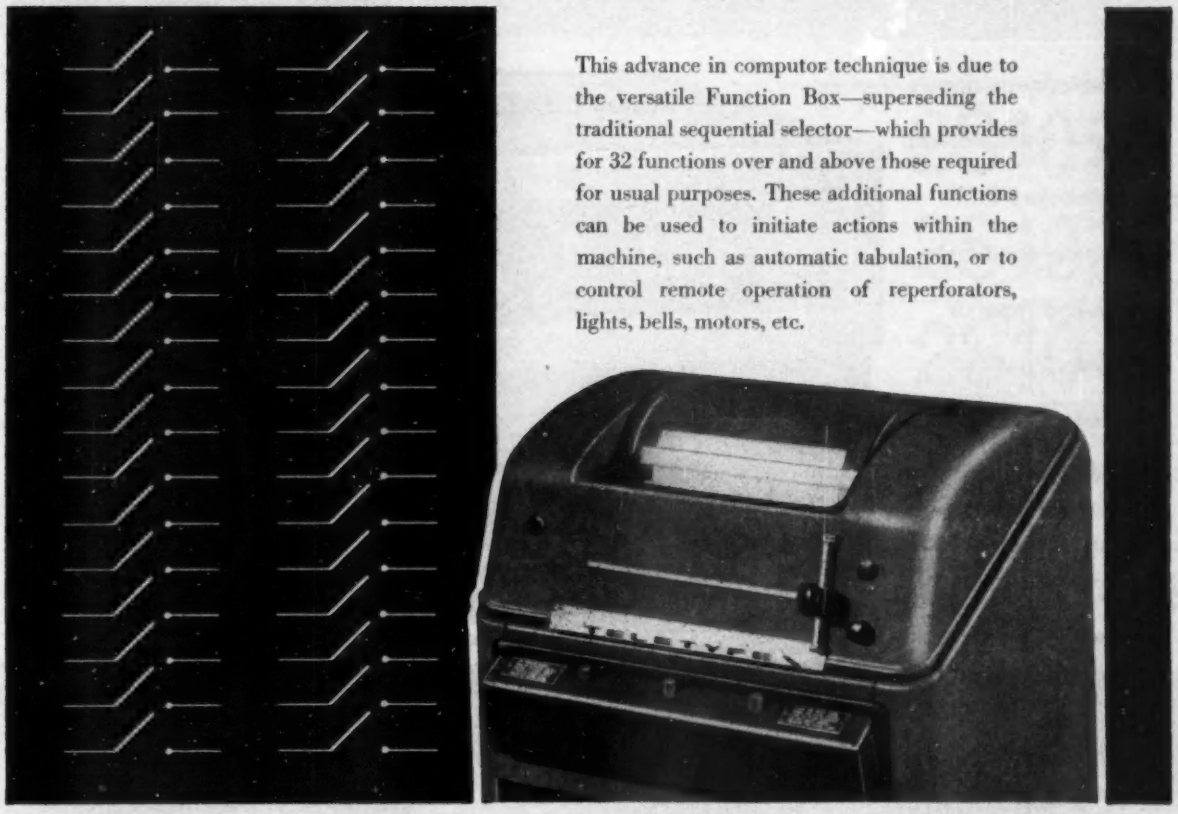
ACCENT ON ACCURACY ...AND SPEED

This new read-out system brings greatly increased speed to what has always been the slowest stage in computor operation. With the Model 28 Page Printer it is possible, by using code combinations, to perform local and remote functions without sacrificing a single character code combination.

UNIQUE DIRECT READER FOR COMPUTORS AT A MODERATE COST



This advance in computor technique is due to the versatile Function Box—superseding the traditional sequential selector—which provides for 32 functions over and above those required for usual purposes. These additional functions can be used to initiate actions within the machine, such as automatic tabulation, or to control remote operation of reperforators, lights, bells, motors, etc.

No larger than an electric typewriter and with interchangeable typing heads, the Model 28 Page Printer requires little or no maintenance. Send for full details to:

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1 Mc/s Counter with In-line Readout for less than £350

New techniques enable Venner to offer a transistorized frequency and time measuring equipment with in-line readout at a lower cost than ever before.

The treble-3-six is proof that Venner gives a high technical performance AND versatility at low cost.

- ✳ Frequency measurement to 1 Mc/s.
- ✳ Multi-period measurement over 1 to 10^7 cycles.
- ✳ Oven-controlled crystal.
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SILICON MESA TRANSISTORS

which perform
the functions of
practically all other types
in one compact
low-priced range

2S102
2S103
2S104

NPN DIFFUSED JUNCTION MESA TRANSISTORS FOR SMALL SIGNAL APPLICATIONS

	V_{CB}	f_T	β
2S102	60 V max.	120 Mc/s	20 - 50
2S103	60 V max.	135 Mc/s	40 - 100
2S104	60 V max.	150 Mc/s	90 - 200

d.c. to 100 Mc/s

–and for nanosecond switching or V.H.F. circuitry–the NEW TEXAS XB26 Silicon NPN EPITAXIAL mesa transistor

	in the TO-18 case	V_{CB}	f_T	β	for 25 Mc/s saturated switching and amplifiers up to 200 Mc/s	
		15V	300 Mc/s	20		

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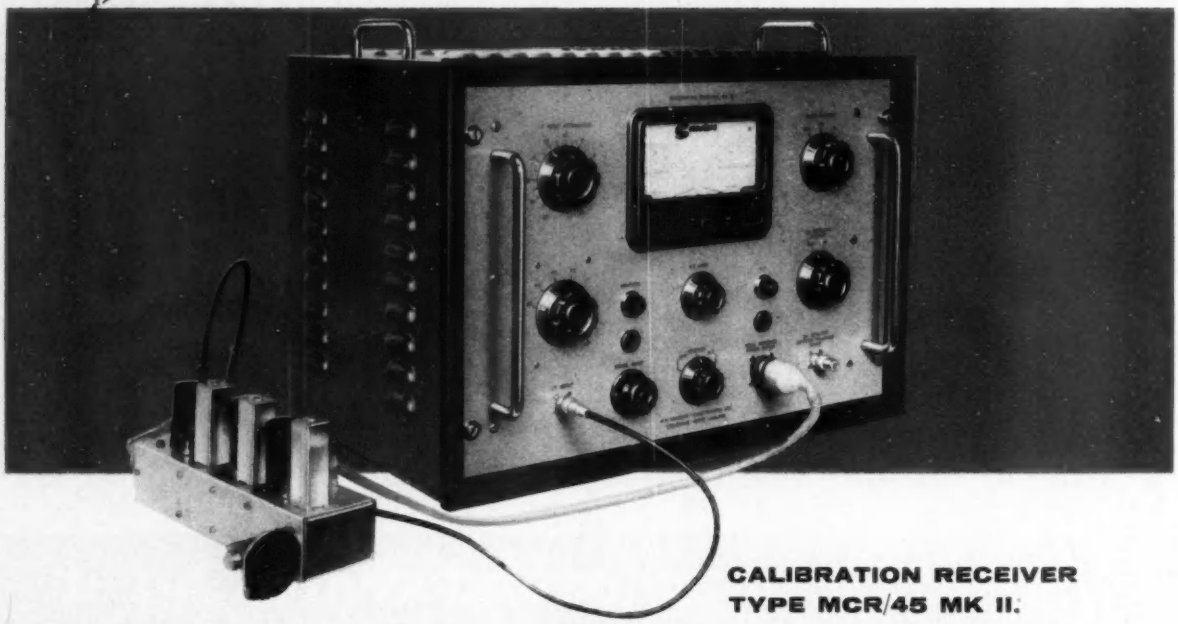

CALIBRATION RECEIVER TYPE MCR/45 MK II.

This versatile receiver will solve rapidly and accurately your problems relating to noise figure measurements by the I.F. attenuation method, calibration of R.F. attenuators using the hetrodyne technique and the many problems associated with microwave spectroscopy circuitry.

The receiver consists of a high gain, low noise figure receiver, with a secondary standard of attenuation. It is designed to operate with the complete range of Sanders microwave crystal mixers, and in combination with a suitable local oscillator, becomes a sensitive detector of microwave energy.

Specifications

Noise Factor: 1.8 to 2.5 db
I.F. Frequency: 45 mc/s
Bandwidth: 2.0 mc/s

Attenuator Accuracy:
Cumulative Error: not greater than ±0.5 db
Fine Attenuator: not greater than ±0.2 db

This is one of a series of new instruments and components by

THE Sanders GROUP OF COMPANIES

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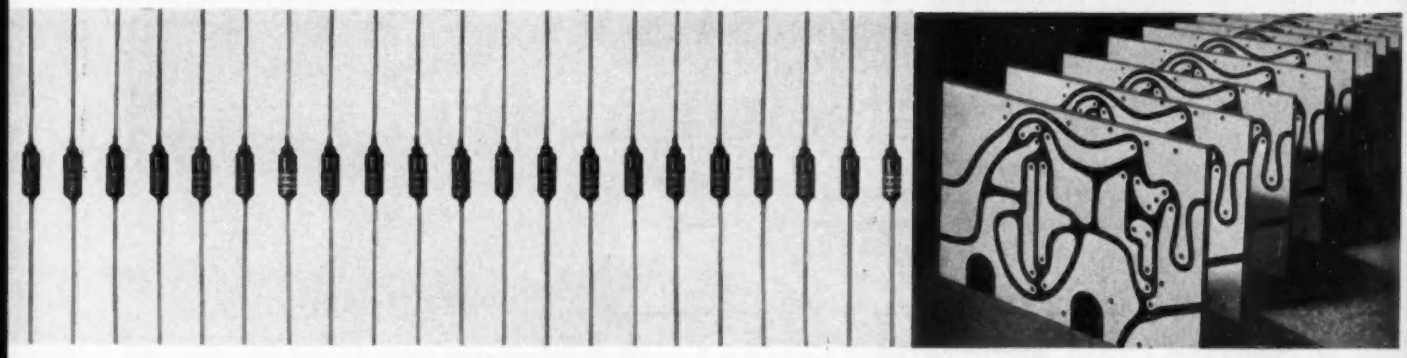
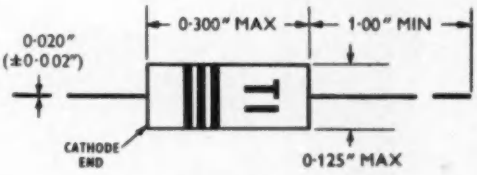
Inexpensive General Purpose
SIGNAL DIODES



TEXAS 1S120 SERIES – 200 mA · 150 V
Standardised small size MOLY/G* case aids Automatic assembly of electronic equipment

maximum ratings		1S120	1S121	
Peak Inverse Voltage at −65°C to +150°C	V_{RM}	50	150	V
Average Rectified Forward Current at +25°C	I_O	200	200	mA
Average Rectified Forward Current at +150°C	I_O	50	50	mA
Recurrent Peak Forward Current at +25°C	$I_{F(pk)}$	2·5	2·5	A
Non-recurrent Surge Current for 1 second at +25°C	i_F	1·5	1·5	A
Non-recurrent Surge Current for 1 second at +150°C	i_F	1	1	A
Operating Temperature, Ambient	T_{amb}	−65°C to +150°C		
Altitude		100,000 ft.		



characteristics				
Max. Reverse Current at P.I.V. at +25°C	I_R	0·1	0·1	µA
Max. Reverse Current at P.I.V. at +100°C	I_R	10	10	µA
Max. Voltage Drop at I_F = 200mA; at +25°C	V_F	1·0	1·0	V

The 1S120 Series is composed of two inexpensive general purpose devices, the 1S120 and 1S121. They are housed in the same hard glass envelope with axial leads as the 1S7000 Series Zener Reference Diodes, the 1S914 and 1S916 Computer Diodes and the 1S111 Series Rectifiers. This standardisation of enclosure considerably facilitates automatic assembly of electronic equipment, particularly where printed circuits are used.

Full Type Approval has been granted to the 1S121, and it is available ex-stock as the CV7040.

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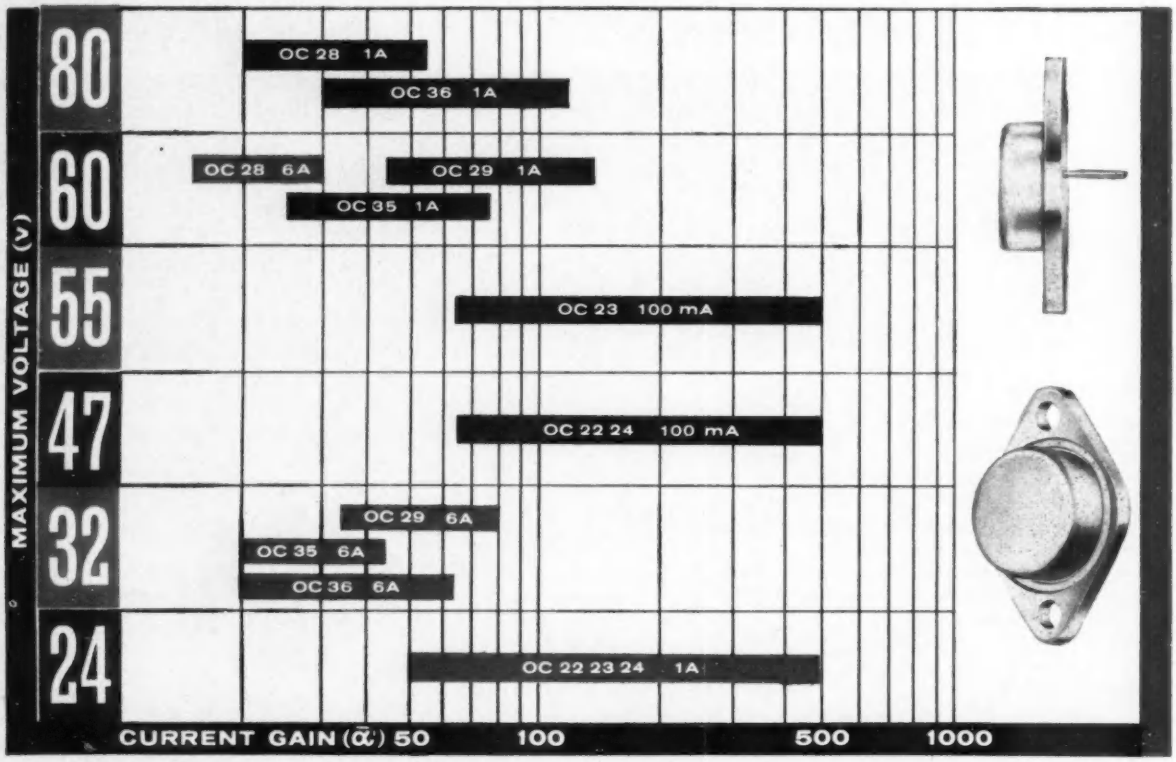
GERMANIUM POWER TRANSISTORS

are best selected from this chart

— then you should contact the MULLARD technical information service, who will give you all the data you need to confirm your choice.



RED is maximum allowable collector-emitter voltage at maximum continuous current.

BLACK is maximum allowable collector-base voltage Vcb max. (Ie = 0).

Here is a guide to recommended applications:

- ★ **OC22** for high quality industrial audio
- ★ **OC23** for ferrite memory core drive
- ★ **OC24** for r.f. power applications
- ★ **OC28** for d.c. converters (24V version)
- ★ **OC29** for extra high gain
- ★ **OC35** for general purpose, low cost application
- ★ **OC36** for general purpose, high power audio and d.c. converters (12V version)

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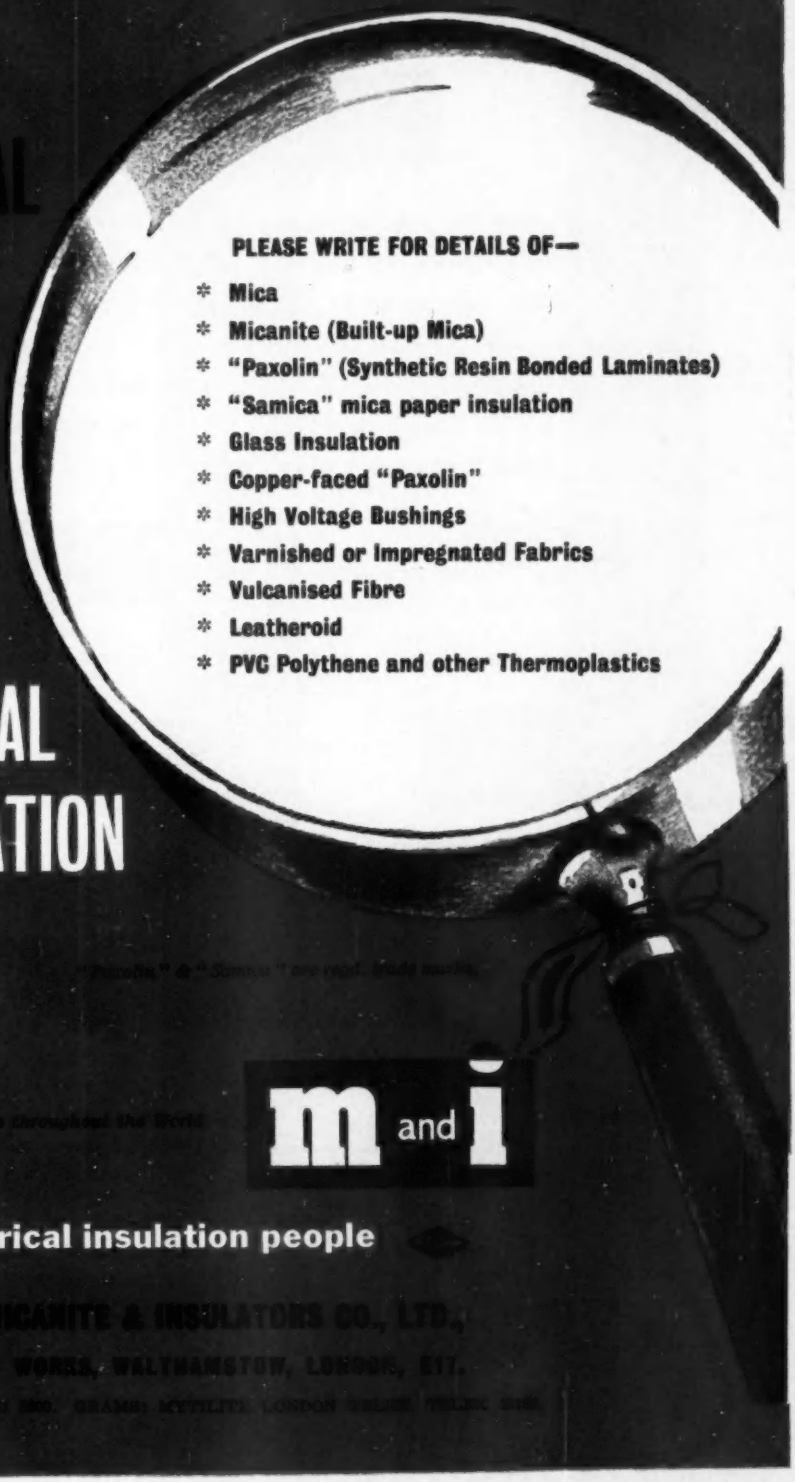

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I^2R means useful heat or wasted power—it just depends on the application. But whichever way you look at it you achieve maximum efficiency when you select from the range of Mullard Power Control Devices.

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Type No.	Max. kVA (2 tubes in anti-parallel)	Type No.	RATING
5551A	600	5555	150 amps at 2.1 kV per tube 200 amps at 900 V per tube
5552A	1200		
2052A	1200		
5822A	Special 3-phase type		
5553B	2400		

THYRATRONS

Type No.	Max. cont. Current
XR1-1600A	1.6A
XR1-3200A	3.2A
XR1-6400A	6.4A
XR1-12	12.5A
XG2-6400	6.4A
XG1-2500	2.5A
XG2-12	12.5A
XG2-25	25A

SILICON CONTROLLED RECTIFIERS

Type No.	Max. cont. Current	Type No.	Max. cont. Current
BTZ 18	4.7 amps (200 volts)	BTZ 20	16 amps (200 volts)
BTZ 19	4.7 amps (400 volts)	BTZ 21	16 amps (400 volts)

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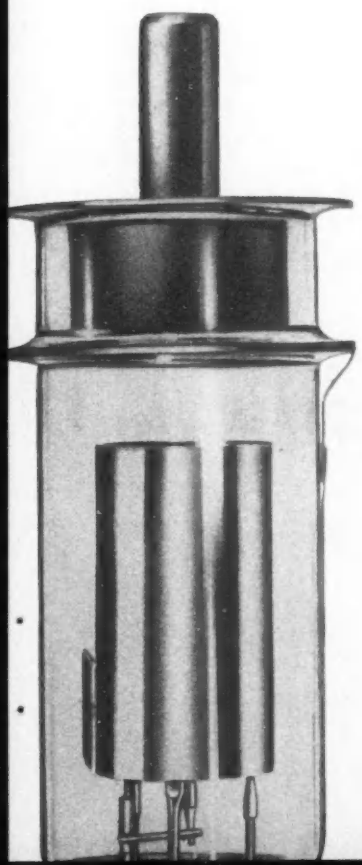
have 18 answers

to your Power Control Problems

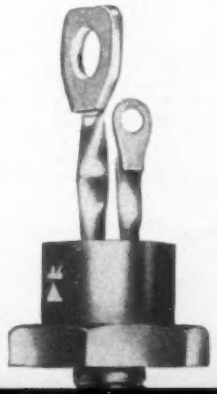
If it's a problem of Power Control in the range up to 2,400 kVA—Mullard have the answer. In fact, there are now no less than eighteen Mullard devices in this range—for motor control, lighting control, resistance welding, impulse magnetising, furnace control, power rectification and many other specialised applications. The three categories of Mullard Power Control devices—Ignitrons, Thyratrons and Silicon Controlled Rectifiers—are briefly discussed in these pages. If you would like more detailed information, please write to the address below quoting reference D 4093.

THYRATRONS Both rare gas and mercury vapour thyratrons are available in the Mullard range—with continuous current ratings up to 25 amps and inverse voltage ratings above 1,500 volts. Mullard thyratrons are not only suitable for direct power control but also for driver service with Mercury Pool devices.

IGNITRONS Water-cooled and thermostatically protected, these internationally interchangeable ignitrons are ideally suitable for resistance welding control up to 2,400 kVA and continuous power rectification up to 200 amps per tube. They have an unusually high ignitor sensitivity, and exceptionally long operational life, even under the most arduous conditions.



SILICON CONTROLLED RECTIFIERS Here, too, is a comprehensive range, with continuous ratings up to 16 amps at 400 P.I.V. Mullard Silicon Controlled Rectifiers are particularly suitable for use in equipment where instantaneous operation is needed. No heater power is required and their small size is of considerable advantage for compact equipments.



MVTB 409

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VHF

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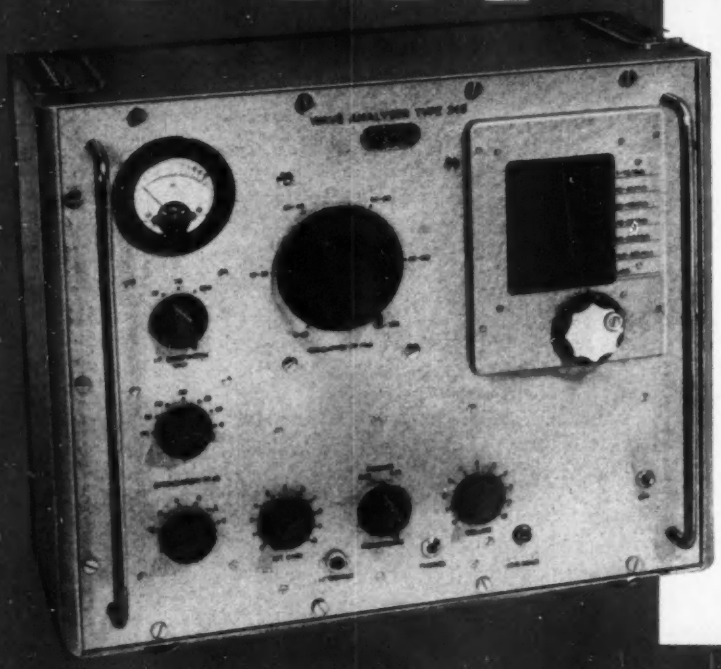
VHF WAVE ANALYSER

TYPE 248

is the ideal instrument for the Harmonic Analysis of Wave Forms



With the WIDE RANGE of 5 Mc/s to 300 Mc/s in 6 bands

AND OTHER POWERFUL FEATURES

Long Scale—4 feet on each band.

Accurate Attenuators—±0.1 dB per step (0—70 dB). Two external 20 dB attenuators provided—accuracy ±0.3 dB.

Low Harmonic Generation—enabling detection of 2nd harmonics to −55 dB and higher harmonics to −70 dB relative to fundamental.

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I.F. Output at socket on front panel.

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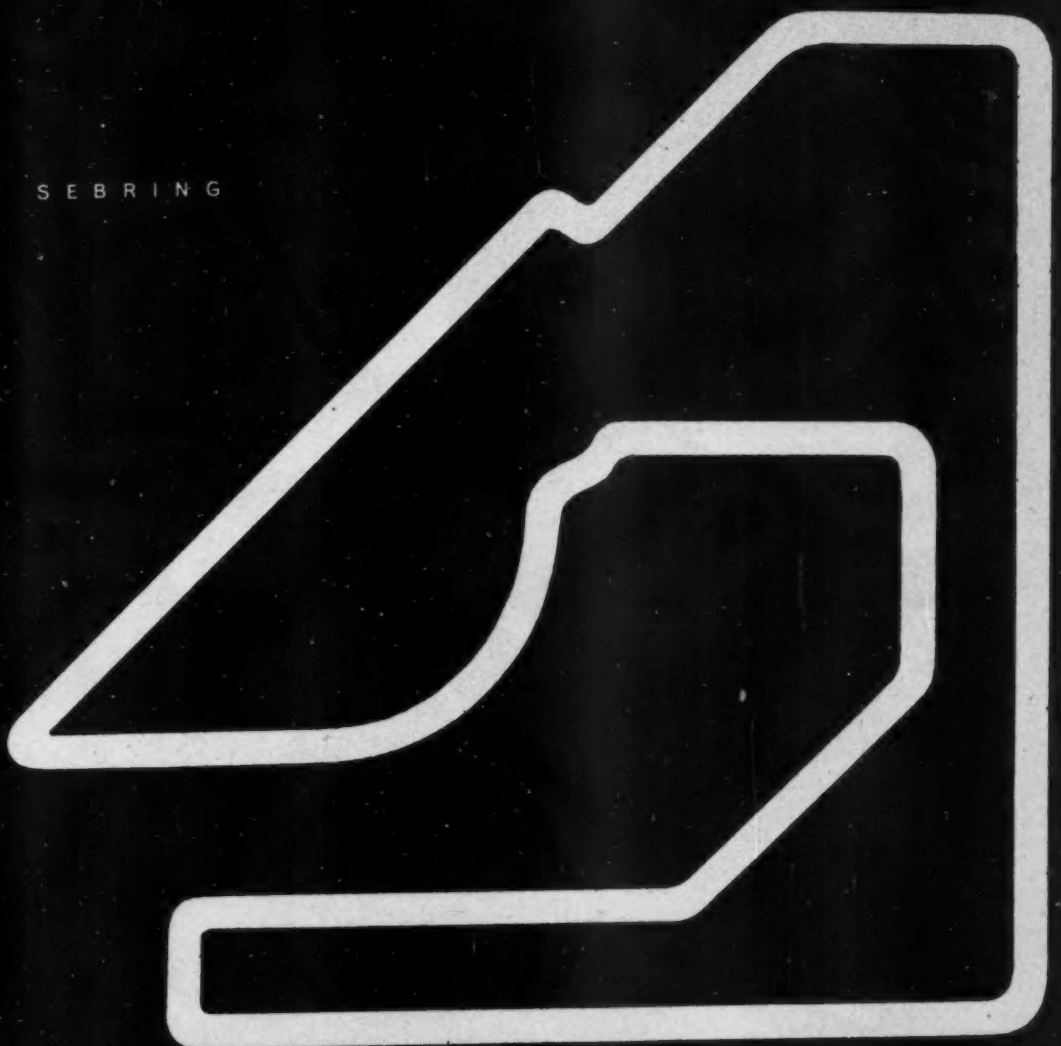
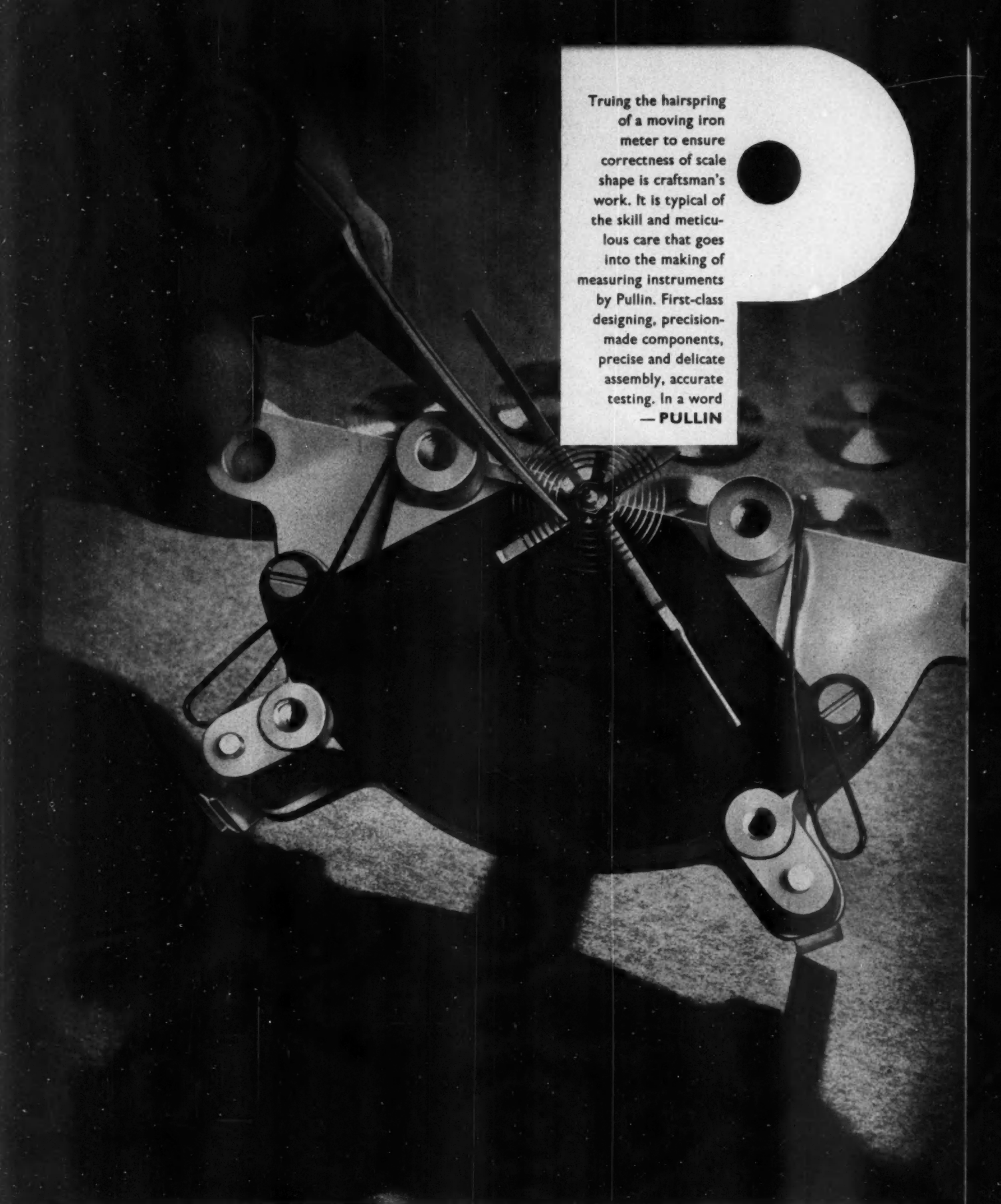


Both you and the racing driver would agree that all circuits have their own characteristics and problems . . . . . .

but for *you*, when selecting a valve for all round optimum performance . . . . . .

better make it BRIMAR

BRIMAR LIMITED FOOTSCRAY SIDCUP KENT FOOTSCRAY 3333 BVA



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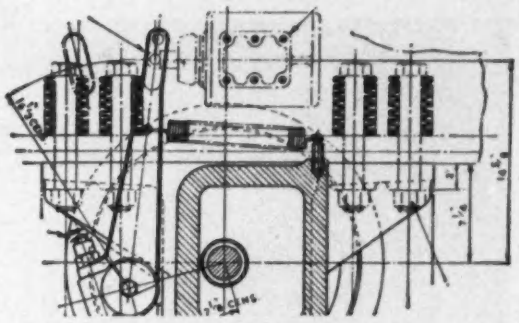
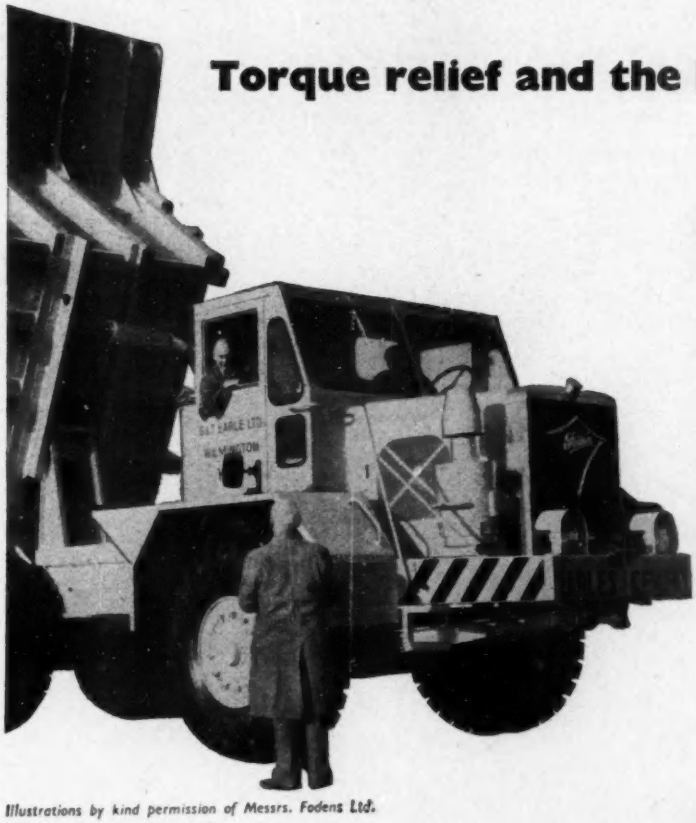


Torque relief and the Belleville Washer



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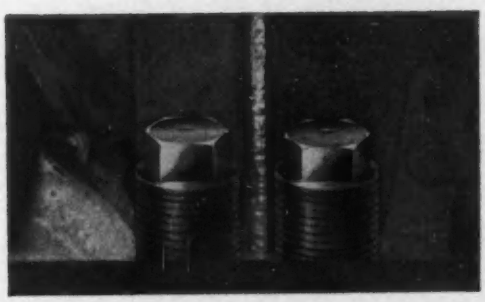
Messrs. Fodens Ltd., fit Belleville washers in packs of 7 pairs on their F.R.6/45 Heavy Duty Dumper. This proved to be the most effective method of relieving twisting of the rear axle case produced by braking and transmission torques.

The potential uses of Belleville washers are endless.

They provide the perfect answer to engineering problems where resistance to load or thrust is beyond the capacity of helical springs. Their fractional movement under heavy load has solved design difficulties in almost every industry.

Salter technicians can help you. Their services are freely at your disposal.



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Here is a summary of information:

* **Fitted with one (normally open) heavy duty contact**
* **Max. rating: 10 amps at 240V A.C.**
  20 amps at 30V D.C. non-inductive
* **Weighs only 2½ ounces**
* **Coils can be vacuum impregnated (to meet general M.O.D. spec. Def. 5000)**

Further details of this relay which can be modified to meet individual requirements, are available from

B&R RELAYS LIMITED

B & R RELAYS LIMITED · TEMPLE FIELDS · HARLOW · ESSEX

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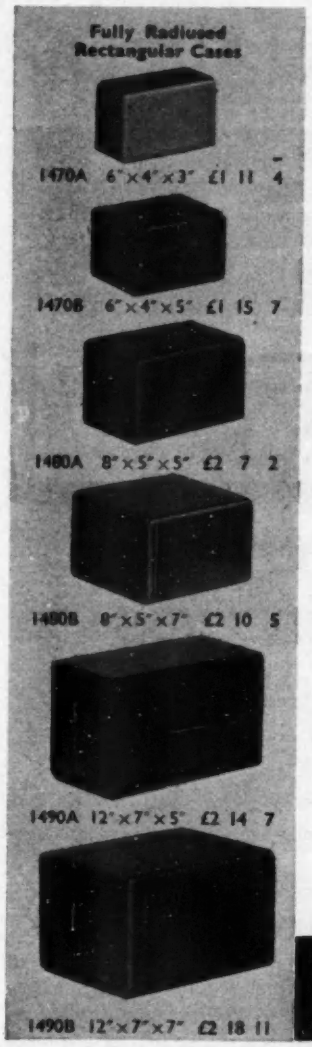
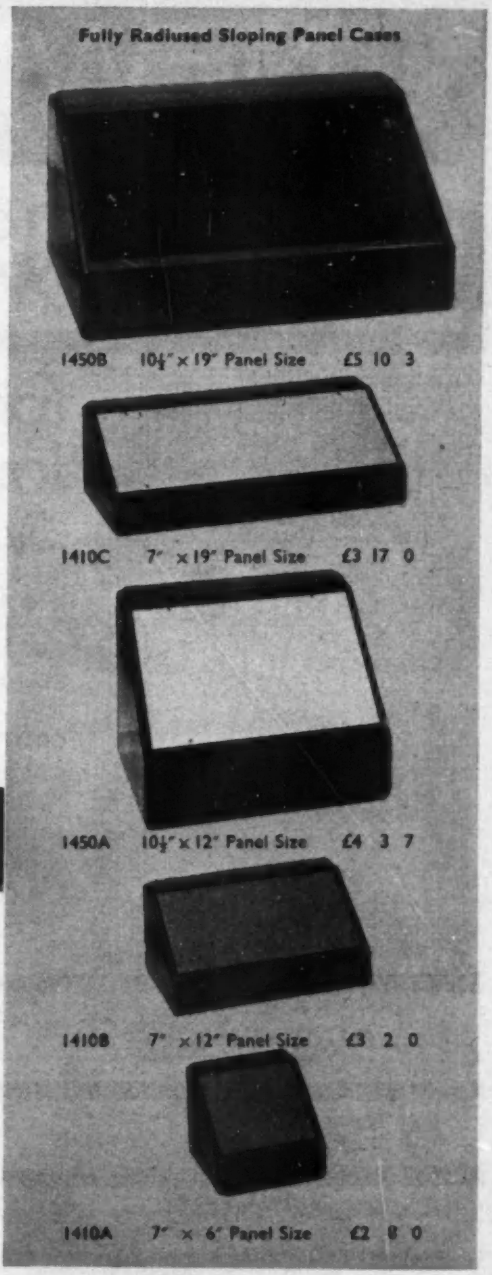


7 days delivery for small and miniature standard cases at really *LOW PRICES!*

15 Imhof standard cases with panel sizes from 6"×4" to 24"×10½". Just look at these examples . . . compare the low prices. Here's real value for money! Whatever the size—whatever the quantity—all these cases are built to the same robust specification and high finish as the existing Imhof Standard Range. Top quality and rock-bottom prices result from Imhof's streamlined methods and full tooling for large-scale production in Europe's most modern factory fully equipped for quality manufacture of cases, racks and consoles.

IMHOFS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1410B 7" × 12" Panel Size £3 2 0
1410A 7" × 6" Panel Size £2 8 0

These cases have been designed as a result of the fast development in miniaturisation of electronics and electrical instruments. The cases are of two types: with sloping front panels, and rectangular cases with vertical front panels. Both types are available in standard duo-tone finishes. Imhofs have also produced a chassis incorporating fixing brackets especially for these cases.

Also available are 9 sizes of MINIBOXES made from 18 swg aluminium to a firmly utilitarian two-piece design—each of the two halves forming three sides of the box. Sizes from 3"×1½"×2½" to 17"×4"×5". Prices from 7/2 to 26/7. Please ask for full details.

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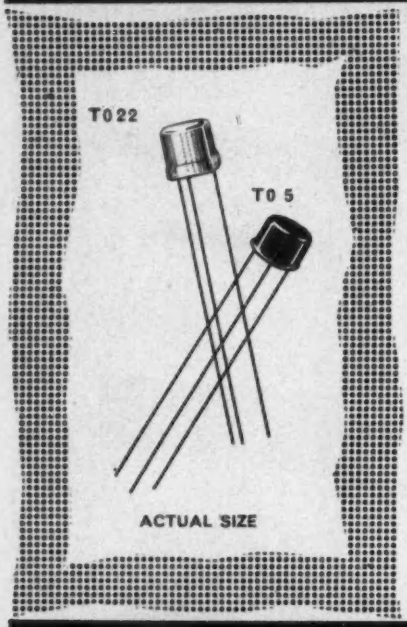


for all fast-switching low-wattage circuits

AVAILABLE IMMEDIATELY IN QUANTITY

QUALITY Assured by tighter-than-ever specifications.

RELIABILITY Based on special heat-ageing, hermetic-sealing and leak-testing processes.

COMPATIBILITY Provided by industry-preferred encapsulations.

COMPETITIVE PRICES Through increased economic production.

The computer engineer is sure to find a unit in the following flexible range of pnp germanium alloy transistors—whatever his circuit requirements. All have a rating of 20V and a minimum DC beta of 50 at the currents stated. Switching speeds are indicated below by fc_o limits but can be provided to f_1 or any other switching specifications. Units are available in standard T022 or T05 encapsulations.

SPECIFICATIONS	VERY HIGH SPEED fc_o = 15 Mc/s upwards	HIGH SPEED fc_o = 7-14 Mc/s	MEDIUM SPEED fc_o = 3-6 Mc/s
HIGH CURRENT (500mA) (Core Drivers etc)	NKT 101	NKT 102	NKT 103
MEDIUM CURRENT (25mA) (Mid-Level Logic Circuits)	NKT 104	NKT 105	NKT 106
LOW CURRENT (1mA) (Analogue DC Amplifiers, etc)	NKT 107	NKT 108	NKT 109

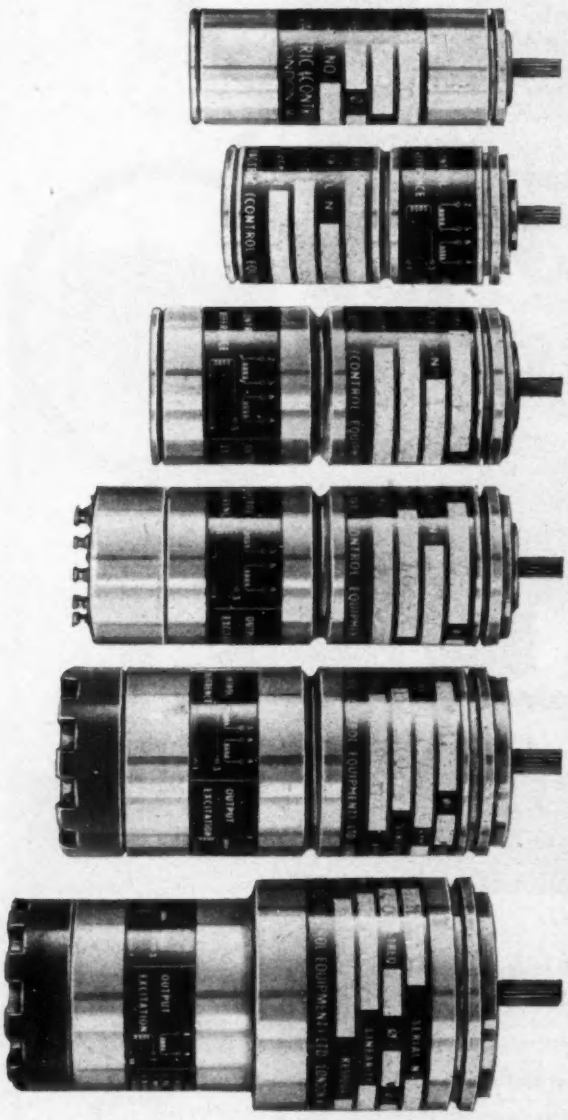
(NKT) **NEWMARKET TRANSISTORS LTD.**
EXNING ROAD, NEWMARKET Tel: Newmarket 3381

MEMBER OF THE PYE GROUP OF COMPANIES

EE 31 051 *for further details*

Vactric

A.C. Servo Motor Tachogenerators



INTERNATIONAL FRAME SIZE

08, 10, 11, 15 & 18

A.C. MOTOR TACHOGENERATORS

. . . provide the required stability for servo systems. They are miniature precision built components of low inertia, low residual and good linearity. They conform to Ministry of Aviation Specifications which require normal operation for 1000 hours at altitudes up to 60,000 feet.

Performance Data

SIZE 08
Std. 2-phase 26v. 400 c/s motor
Tachogenerator output 0.3v/1000 r.p.m.
Residual 20 m.V. max., Linearity ±0.5%
Weight 82 grams.

SIZE 10
Std. 2-phase 26v. 400 c/s motor.
Tachogenerator output 0.4v/1000 r.p.m.
Residual 20 m.V. max., Linearity ±0.5%
Weight 108 grams.

SIZE 11
Std. 2-phase 115v. 400 c/s motor.
Tachogenerator output 0.5v/1000 r.p.m.
Residual 20 m.V. max., Linearity ±0.5%
Weight 200 grams.

SIZE 11 (with temperature compensation)
Std. 2-phase 115v. 400 c/s motor.
Tachogenerator output 0.45v/1000 r.p.m.
±3.5% over −40°C to +100°C or
±1.5% over −20°C to + 80°C. } Body Temp.
Residual 20 m.V. max., Linearity ±0.5%
Weight 235 grams.

SIZE 15
Std. 2-phase 115v. 400 c/s motor
Tachogenerator output 3.0v/1000 r.p.m.
Residual 20 m.V. max., Linearity ±0.2%
Weight 400 grams.

SIZE 18
Std. 2-phase 115v. 400 c/s 18 A.C. motor.
Tachogenerator output identical to standard size 15 Tachogenerator.
Weight 550 grams.

All units can be supplied with plain shaft or with a pinion shaft permitting in-line reduction gearheads to be directly coupled, reductions up to 1,000,000:1 can be obtained with 2 gearheads in cascade.

** Write or phone for literature dealing with our expanding range of Control Equipment.*

Vactric (Control Equipment) Limited

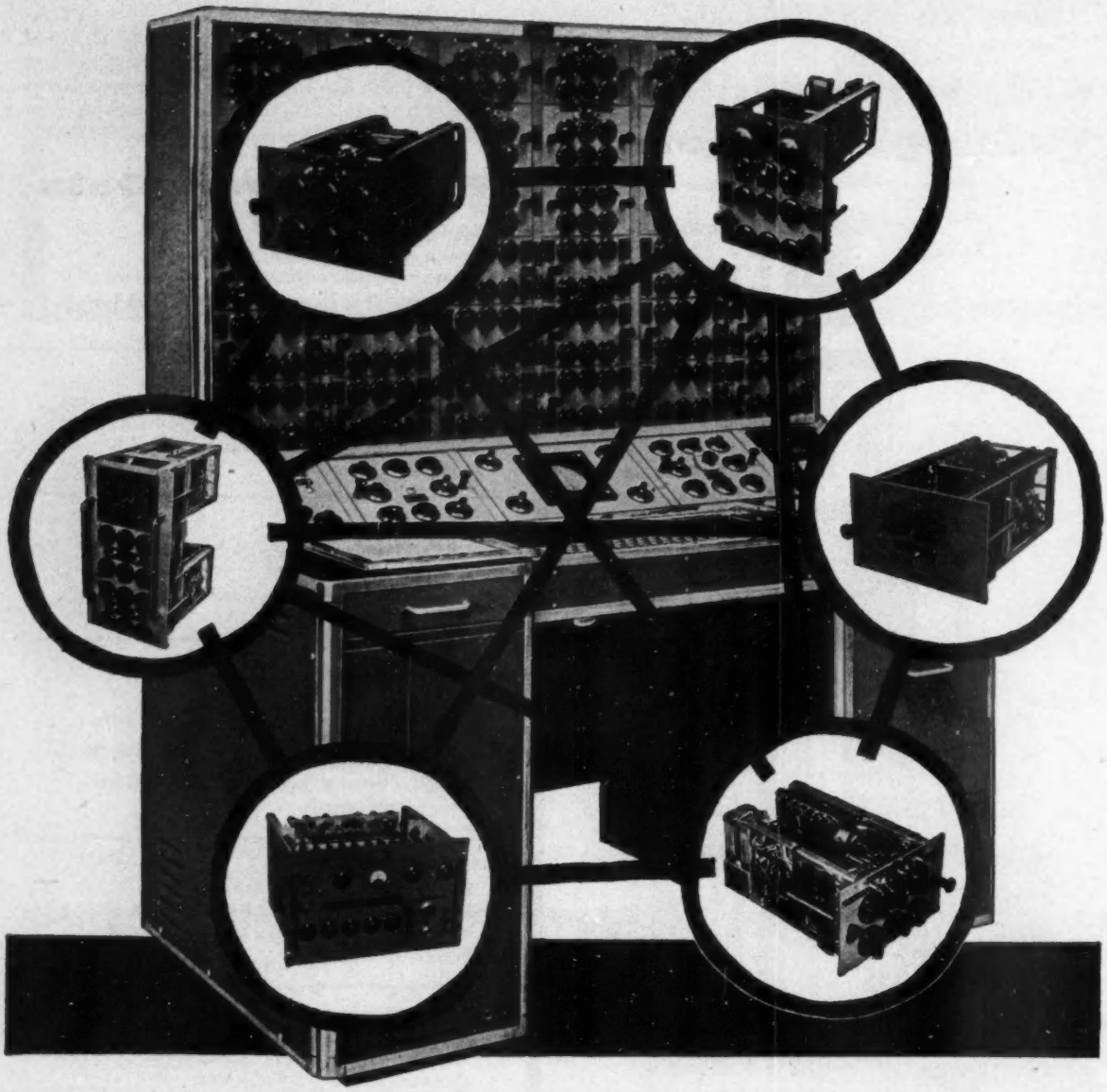
Vactric House, Sloane Street, London, S.W.1. Telephone BELgravia 7000

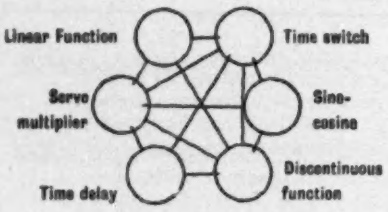
NRP 5007

EE 31 052 *for further details*

Shorts General Purpose Analogue Computor

The computor with the widest range of units

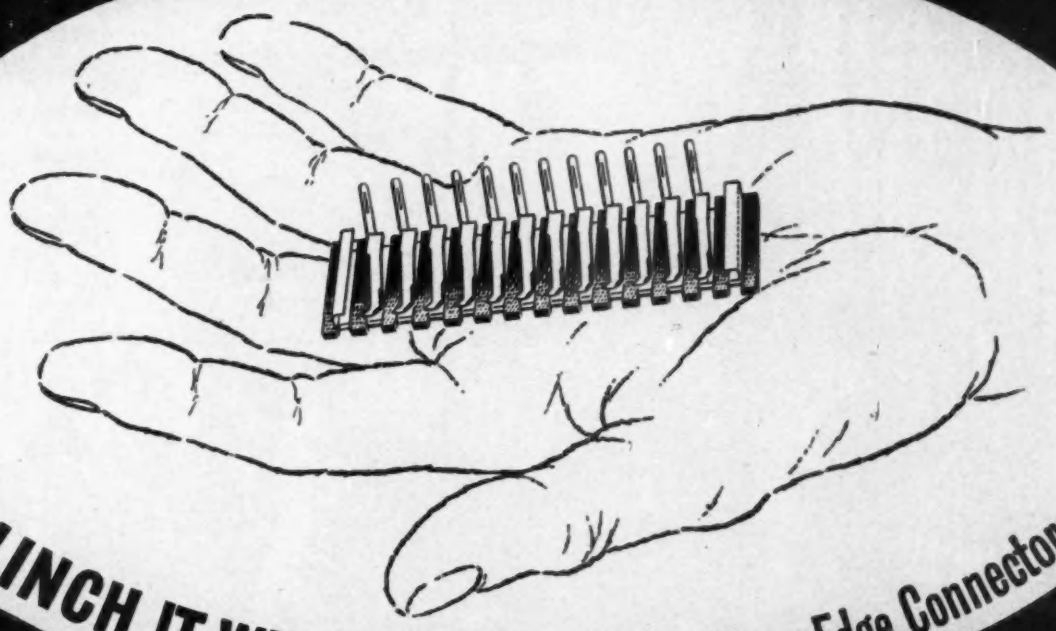




- In service throughout the world
- Patching without cords
- Fast repetitive or continuous solution
- Switch set coefficients and transfer functions
- Units quickly interchangeable
- Display, power supplies, and timing contained within console

Write for illustrated brochure and data sheets to: **COMPUTOR SALES DEPARTMENT, SHORT BROTHERS AND HARLAND LIMITED**

East India House, 208a Regent Street, London, W.1



CLINCH IT WITH CINCH Printed Wiring Edge Connectors

FAST, LOW COST ASSEMBLY

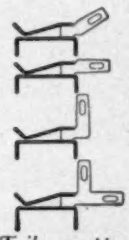
SPECIFICATION

AVAILABLE IN: Any no. of ways up to 40.
CENTRES: 0.150″ or 0.156″ as specified.
CURRENT RATING: 5 Amps per contact.
WORKING VOLTAGE: 500 V.D.C.
VOLTAGE PROOF: 2 K.V/D.C.
CONTACT RESISTANCE: < 5 m Ω after 1,000 sizings and exposure to DEF.5000 tropical conditions.
WITHDRAWAL FORCE: 4 to 6.5 ozs. per Contact.

CONTACTS: Phosphor Bronze, finished Gold Plate on Silver, Silver or E.T.
Note: 79/480-2 & 79/961-2 Brass only; finish as above.
LAMINATE: Best quality Commercial Grade Grade II; Fibreglass to order. (Fibreglass 0.150″ ctrs. only).
END GUIDES: Hard Brass; finish as above.

79/961-2
79/480-2

SEE US AT A.S.E.E. EXHIBITION, EARLS COURT, MARCH 21-25th

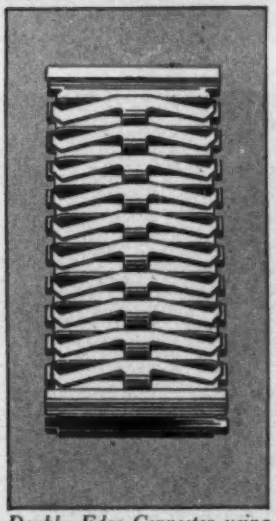


81/006
81/007
81/008
81/009

Tails accept Amp 98 Taper Tab

81/010
81/011
81/012
81/013

Tails accept Amp 78 Taper Tab.



Double Edge Connector using 79/961-2 Contacts

Carr Fastener Company Ltd

STAPLEFORD, NOTTINGHAM.
197 GREAT PORTLAND STREET, LONDON, W.1.
Museum 9361

A SUCCESSFUL LAUNCHING

LAUNCHING OF THE NEW ELIZABETHAN LINE "GLORIANIANA"

Left to right: A. Daley-Noggin (Director), The Hon. Percy Veeryng (Director), Lord Lumme (Chairman), H. H. The Ali Mhin-Yum, K.G.C.I., Lady Phyllis Glassup*, Field Marshal Earp, K.V.C.O., G.C.E., Commander Ivan Astikoff (Naval Attache, Slobovia), D.d'I. Dick, O.B.I.T.

** (who was, of course, Miss Elsa Poppin before her brilliant marriage earlier this year to Lord Bung's son, Toppis.)*

Photo. "Gates heads Chronicle" *with thanks to Moss Bros.*

"CONGRATULATIONS CHAIRMAN—

we saved an extra £25.000 by using*

CONTINENTAL ALUMINIUM"

** Standard Continental Aluminium Sheets, Sections, Tubes, etc., sell at £20 per ton less than normal approximately according to size and quantity. Guaranteed new and to British Standard Specifications.*

H. ROLLET & CO. LTD.

The largest distributors of British & Continental Non-Ferrous Metals

Since 1896

Depots in most major cities

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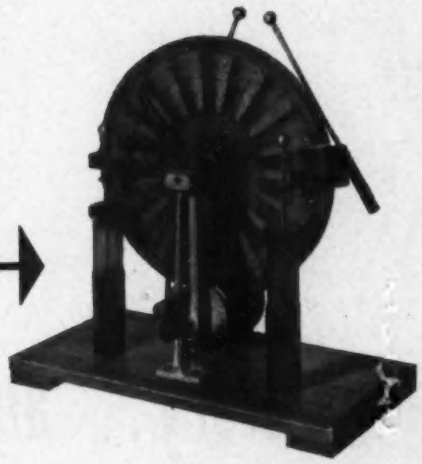
1885 WIMSHURST Influence Machine

During the years 1878-1888 Mr. James Wimshurst contributed considerably to the science of physics by designing and constructing a number of High Voltage Generators of the type shown in the illustration.



1961 HURSANT ELECTRONICS

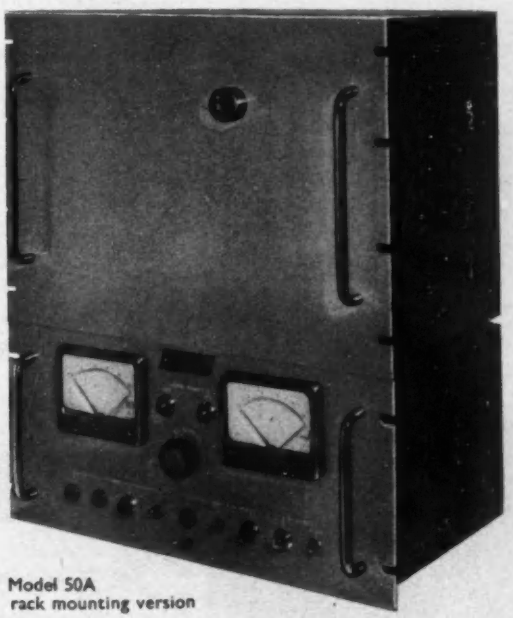
are proud to announce their new range of regulated high voltage supplies which are of equal interest to the physicist and research engineer of today.

Model 30B	0-30KV	—2MA'S	£185
Model 50A	0-50KV	—1MA	£240
Model 100A	0-100KV	—700μA'S	£340
Model 150A	0-150KV	—500μA'S	£450

All models listed have continuously variable and reversible polarity output, and are fitted with kilovoltmeters, current meters, and overload trips as standard.

Small Physical Size.

Robust construction, low ripple and good regulation are also features of these supplies which are offered at the prices shown above.



Model 50A
rack mounting version

A leaflet giving further details is available on request

HURSANT ELECTRONICS LTD

13-14 The Mall Ealing W.5.

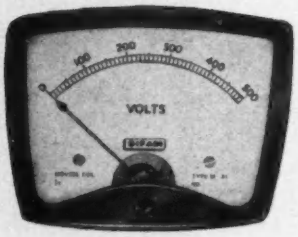
Telephone: EALing 7176

A·S·E·E
ELECTRICAL ENGINEERS EXHIBITION
EARLS COURT MARCH 21st–25th
VISIT US ON STAND Q. 13

To keep pace with the constantly increasing demand for one of this country's most comprehensive range of precision electrical measuring instruments, the new Sifam factory is now fully operative. Consolidating the resources of two previous plants, this new development, occupying 21,000 square feet, brings together under one roof machine shops, plastic moulding, tool rooms, plating assembly and spray shops.

The new plant is purpose-built specifically for electrical measuring instrument development and manufacture. It is geared to ensure maintenance of high standards of service and product and special attention has been paid to new techniques in air-conditioning, dust-free assembly areas and internal communications.

a new factory... and a new range of instruments...

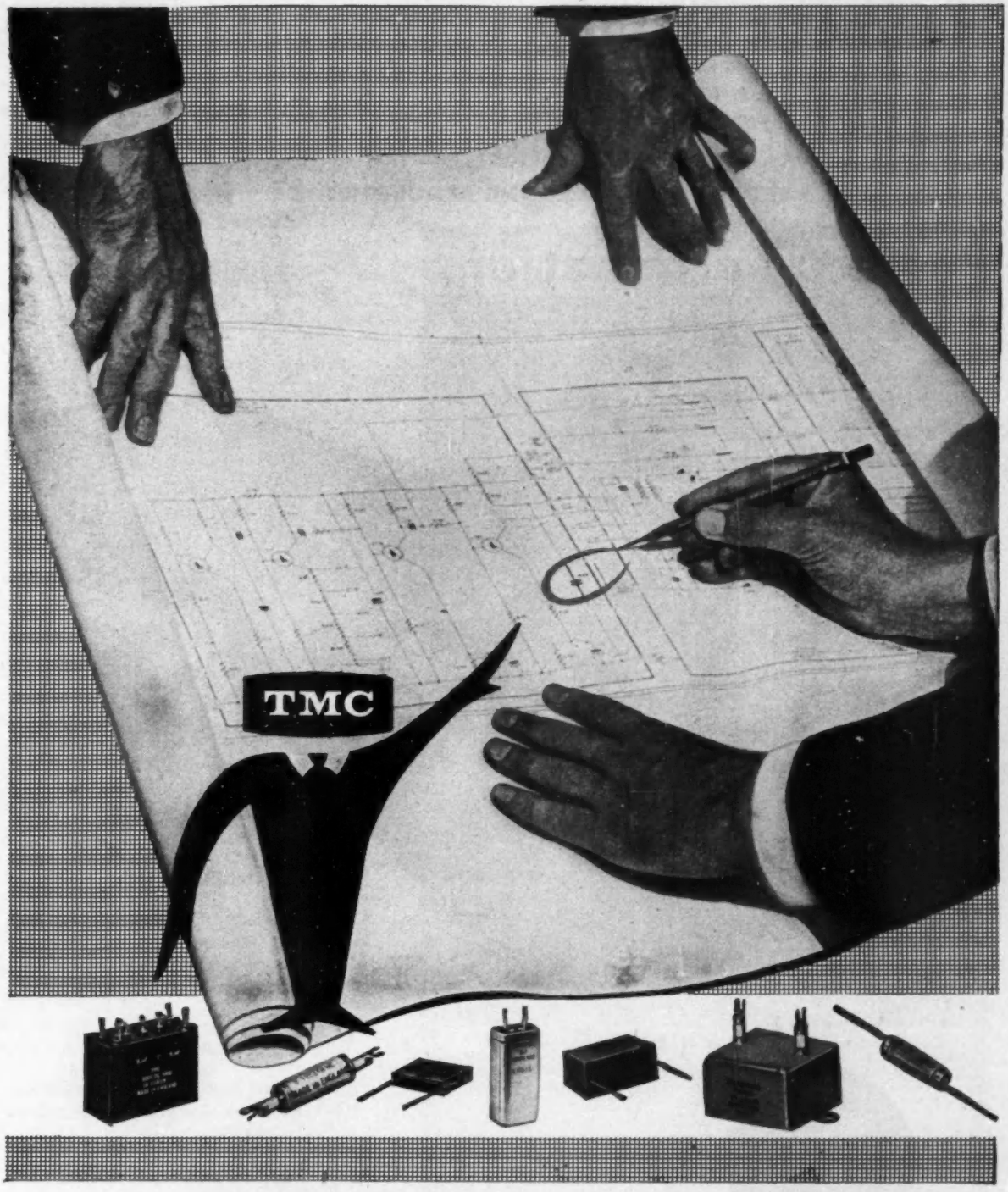


The new Wessex series provides a range of four instruments of notable distinction and clean design. Illustrated are Types 28, 31 and 41.

Sifam
Instrumentation
... skilled craftsmanship and a thirty year old Tradition of Excellence...

Write for full Catalogue information on the newest Sifam Developments.

SIFAM ELECTRICAL INSTRUMENT CO., LTD.,
Woodland Road, Torquay, Devon.
Torquay 63822/3/4 *Telegrams: SIFAM, TORQUAY*



SPECIFY T.M.C. capacitors . . . they are right for the job! The extensive range includes top-quality, precision types which meet the requirements of exacting equipment—but there are, too, the types you'll choose when the equipment is less spectacular and price is the governing factor. So specify T.M.C. and be sure of getting the right capacitor at the right price to do a dependable job.

Please write for further information

TMC

CAPACITORS

TELEPHONE MANUFACTURING COMPANY LIMITED,
Components Division, Cray Works, Sevenoaks Way,
Orpington, Kent. Telephone: Orpington 26611.

EE 31 058 *for further details*

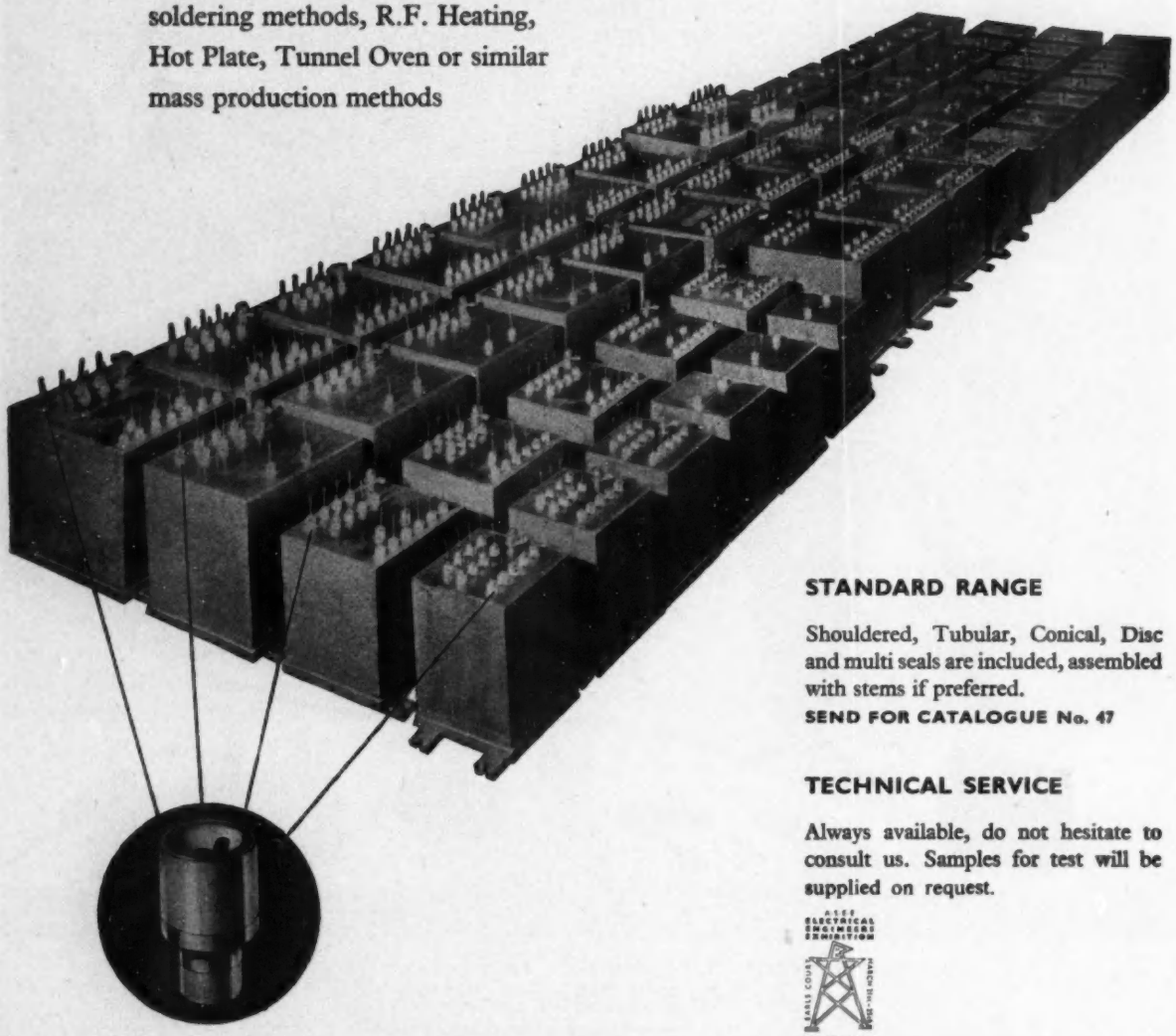
Hermetic Sealing

STEATITE & PORCELAIN
NICKEL METALLISING
Quality Approved (Joint Service R.C.S.C.)
WILL MEET THE MOST EXACTING REQUIREMENTS

METALLISED BUSHES

Perfect Terminations

—made readily without special precautions by semi-skilled labour, employing simple hand soldering methods, R.F. Heating, Hot Plate, Tunnel Oven or similar mass production methods



STANDARD RANGE

Shouldered, Tubular, Conical, Disc and multi seals are included, assembled with stems if preferred.
SEND FOR CATALOGUE No. 47

TECHNICAL SERVICE

Always available, do not hesitate to consult us. Samples for test will be supplied on request.

STEATITE & PORCELAIN PRODUCTS LTD.

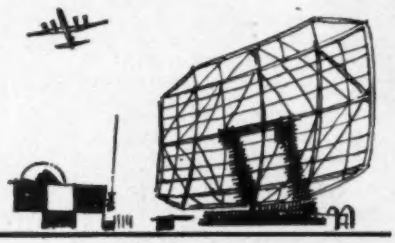
STOURPORT ON SEVERN, WORCS. Telephone: Stourport 2271. Telegrams: Steatain, Stourport

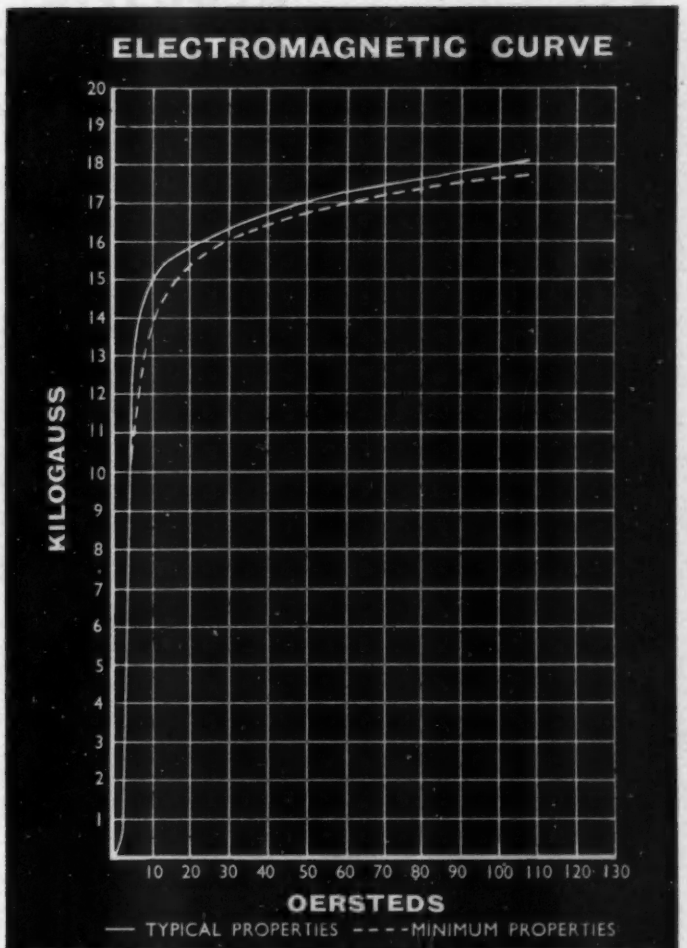
SP100

The excellent electromagnetic properties of

Purefee AND REFINED MAGNETIC IRONS

These special irons are suitable for a wide range of applications in electrical and electronic equipment. After rough machining, followed by annealing treatment, toroidal ring testing results exceeding the minima shown on the table, can be expected.





FIELD STRENGTH (H)		FLUX DENSITY (B)
Ampere Turns/cm	*Oersteds*	*Gauss(minimum)*
3·5	4·40	11,400
6·0	7·54	13,400
10·0	12·57	14,600
20·0	25·13	15,800
50·0	62·83	17,000
80·0	100·53	17,600
REMANENCE		9.000 (*minimum*)

MIDLAND AND LOWMOOR IRON & STEEL CO. LTD.

Rotherham. Telephone: Rotherham 4211/2/3

MI 16

Want to measure Frequency Response of Hearing-Aids, Loudspeakers, and Microphones?

Type MMP21

ACOUSTIC MEASURING EQUIPMENT

The Acoustic Measuring Equipment consists of:

Beat-Frequency Oscillator, type HO12

Range: 2 to 20,000 c/s and 20 to 40 kc/s.
Accuracy: 0·5% + 1c/s.
Drift: Less than 3 c/s per hour after 5 min. warm-up.
Output: Transformer output up to 6 watts with low distortion. Attenuator output from 50 μV to 50 V.

Available with built-in Warbling device and/or 1 Mc/s generator.

Logarithmic Recorder, type NS3

Frequency Range: 30 to 20,000 c/s.
Voltage Ranges: 30, 50, or 80 db (0 db = 10 mV).
Paper Width: 10 cm. (4 in.).
Paper Speed: 0·13 and 0·5 cm. per second.

The Logarithmic Recorder is internally coupled to the type HO12 B.F.O.

High-Gain Measuring Amplifier, type F33

Range: 10 to 40,000 c/s.
Amplification: 10, 20, 30,...100 db.
Noise and Hum: About 2 μvolts referred to input terminals.

Frequency response in accordance with ASA recommendations. Two Amplifier units are used in the type MMP21.

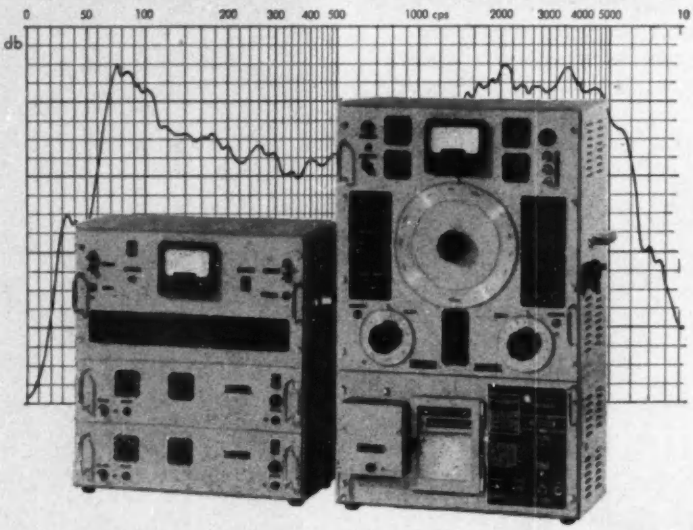
Condenser Microphone and Artificial Ear available for Hearing-aid measurements.

Regulating Amplifier, type SP59

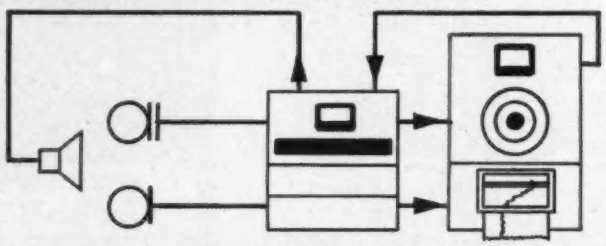
The Regulating Amplifier is used to monitor all signal levels in the system and to provide automatic control of the B.F.O. output.

Radiometer supplies:

AF Oscillators
R-L-C Bridges
Standard Signal Generators
Vacuum Tube Voltmeters
Wave Analysers



The Acoustic Measuring Equipment is specially designed to simplify recording of frequency response curves in the audio-frequency range.
For loudspeaker-recordings the B.F.O. output is controlled to produce either constant current or constant voltage.
For microphone or hearing-aid measurements the sound pressure is maintained at a constant level.
The recorder automatically stops after the completion of a recording, which is made in about 40 seconds. The B.F.O. and recorder are automatically switched on and off at preselected frequencies.



Typical set-up for recording the frequency response of a microphone at constant sound-pressure. The upper microphone is inserted in the control channel which regulates the B.F.O. output. The lower microphone is the specimen under test.

Write for complete information

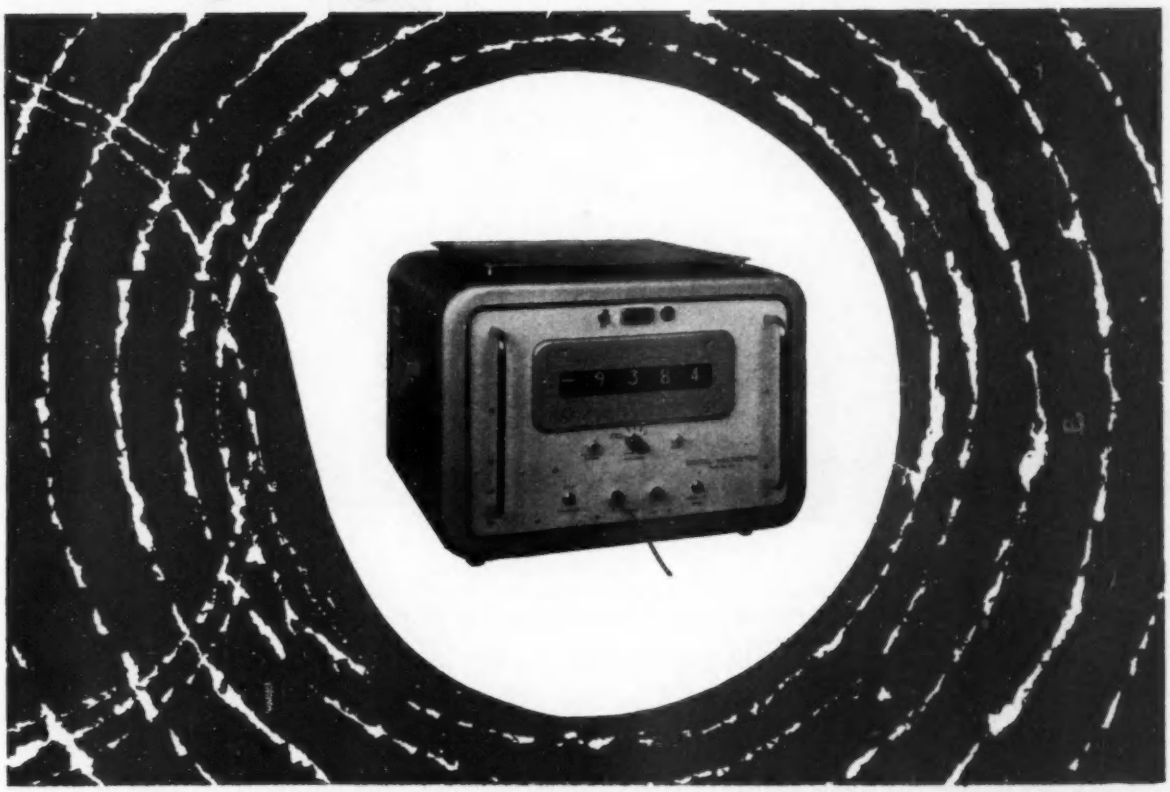
RADIOMETER
72 Emdrupvej, Copenhagen NV, Denmark

Represented in Great Britain by
Livingston Laboratories Ltd.
Retcar Street, London, N.19

EE 31 061 *for further details*

BE DIGITAL VOLTMETER

TYPE BIE2114



This all-electronic digital voltmeter, using an entirely new counting tube, has been designed for application in fields requiring accurate measurements of D.C. voltages. These include computer inputs and outputs, reference supply measurements, strain gauge measurements, production testing of electronic and electrical components and industrial process control (e.g. analogue-to-digital conversion).

- Decimal in-line display
- All-electronic—new counting tube
- 0.05% accuracy
- 103 milliseconds conversion time. Three read-outs per second
- Automatic range and sign selection with indication
- 50 megohms input impedance
- Integral in-line printer drive

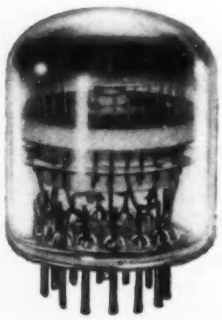
BLACKBURN ELECTRONICS LIMITED

BROUGH YORKSHIRE · TELEPHONE BROUGH 121

Member Company of the Hawker Siddeley Group.

EE 31 062 *for further details*

now, just one small tube counts selects indicates



Here is a tube which can be used either as a counter and indicator, or selector and indicator—just as you require. It's the Mullard Z504S—a 4kc/s tube of all-glass construction. Modern techniques make economically possible these functions in one envelope. The Z504S brings you economies from every angle. It is a remarkably inexpensive tube . . . and achieves some really welcome economies in equipment space. Moreover it is made to close mechanical tolerances and so avoids the need for post-assembly adjustments. *If you would like to know more about the new multi-purpose tube, just write Mullard quoting reference D4103.*

Mullard
GOVERNMENT AND INDUSTRIAL VALVE DIVISION

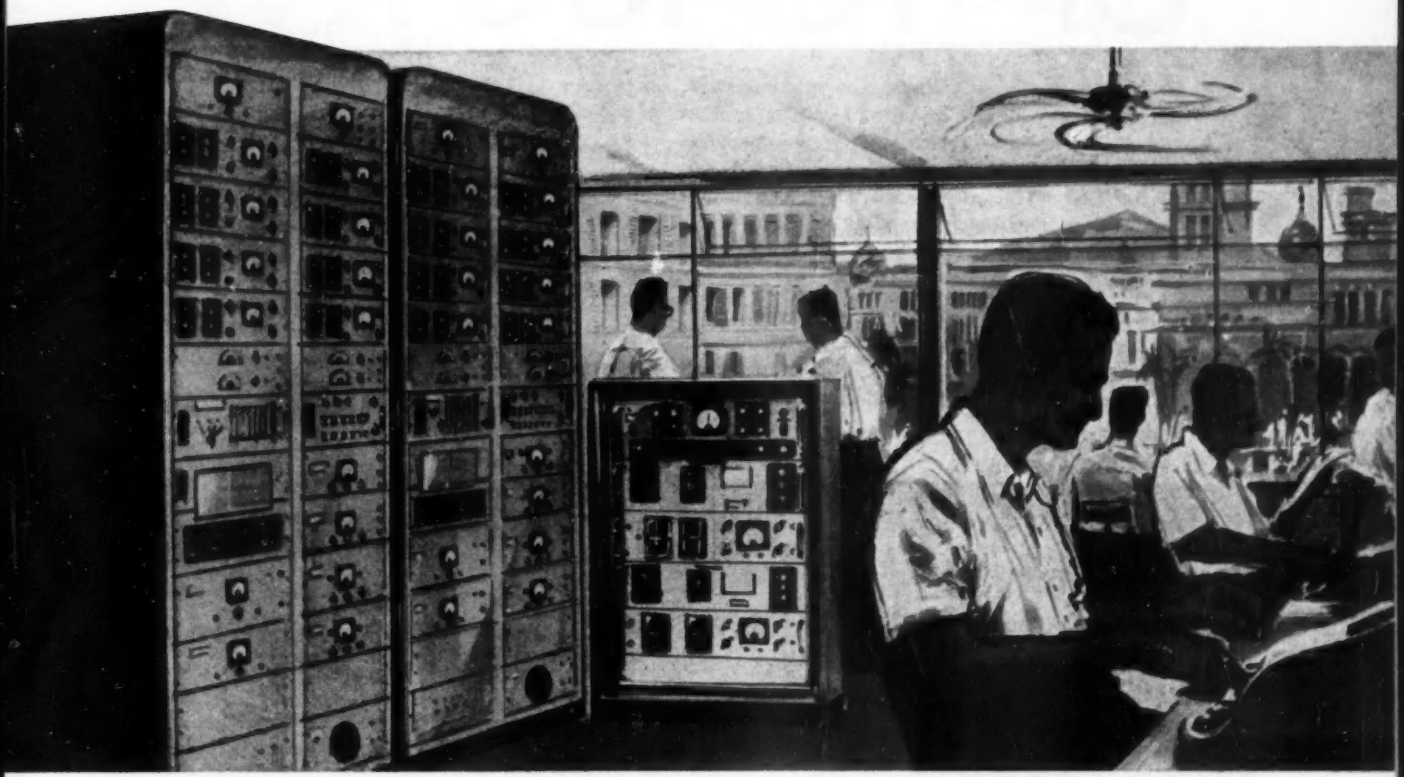
MULLARD LIMITED · Mullard House · Torrington Place · London W.C.1
Telephone: LANgham 6633

MVTB 410

Plessey

TELECOMMUNICATIONS

'speed the news'



Plessey is everywhere, you'll find . . . in New Delhi for example, where the Commonwealth Relations Office has installed Plessey Teleprinter Terminals for the reception of the London Press Service Broadcasts.

The ubiquity of Plessey Radio Teleprinter Equipment is as complete in world meteorology, press and consular services as Plessey Telecommunications is in the total telecommunications field. Other Commonwealth Relations Offices with Plessey teleprinter terminal equipment include Karachi, Salisbury and Colombo. Reuters have similar installations at Benghazi, Athens, Ankara, Hong Kong, Mauritius and Buenos Aires . . . and in Ethiopia and the Lebanon it is employed in civil aviation.

Behind this achievement are the extensive prototype and quality manufacturing resources of the Telecommunications Division, inspired by the work of a unique research and development organisation. The Company recognises the need to segregate advanced thinking from the hustle and distraction of the factory. Accordingly, in addition to the Group Research Laboratories at Roke Manor and other specialised research centres already existing in the U.K., extremely well equipped laboratories have recently been established at West Leigh for advanced telecommunications studies. In these establishments, the next generation of telecommunications equipment is already taking shape.

In close support at all times are the complete resources of the Plessey Group of Companies which include unrivalled tool making and machining facilities, a full range of environmental testing and production laboratories, and the services of the materials laboratories at Caswell.

TELECOMMUNICATIONS DIVISION • ELECTRONIC & EQUIPMENT GROUP
THE PLESSEY COMPANY LIMITED • ILFORD • ESSEX • Telephone: ILFORD 3040
Overseas Sales Organisation : Plessey International Limited • Ilford • Essex • England

TD4

EE 31 064 *for further details*

INDUSTRIAL R.F.
UP TO 100 kW

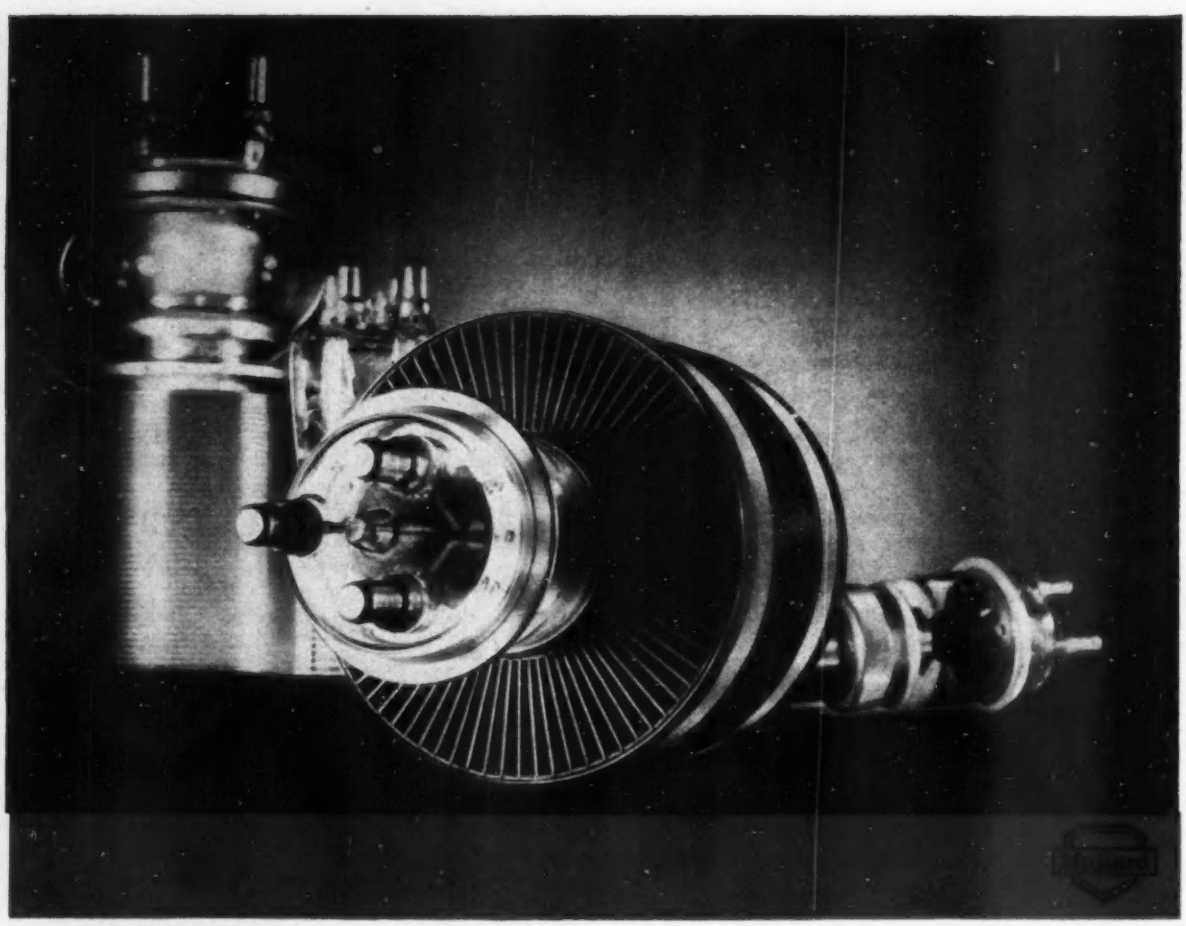
Mullard R.F. Heating Valves cover the power range up to 100 kW, in air and water cooled versions. Five basic valves have been especially designed to meet the requirements of industrial r.f. heating power levels. Each valve is mechanically and electrically robust, and will operate with extreme reliability under varying load conditions, fluctuating mains voltage and mechanical vibration.

Constant Power . . . three of the new series are designed so that output power is substantially independent of load impedance.
The electrical characteristics of these three types have been specially designed to maintain the output power close to nominal over load variations of 3 to 1.

Filaments . . . are made of heavy duty thoriated tungsten, generously rated to provide an adequate reserve of emission—and to accept temporary voltage variations of +5% and −10% of the nominal.

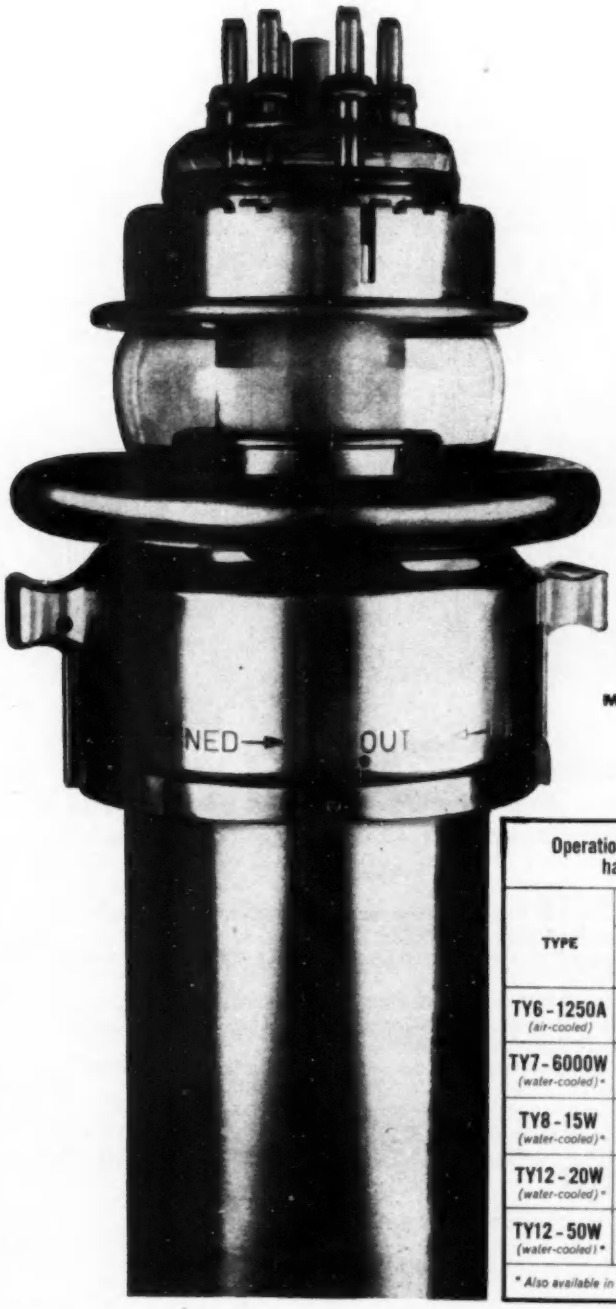
Grid . . . special material and processing give the valves long life under arduous conditions.

Anodes . . . are designed to withstand accidental overdissipation.



EE 31 065 *for further details*

HEATING VALVES



The data presented in this advertisement gives only an outline of the characteristics and performance of the Mullard High Power Range of Industrial R.F. Heating Valves; full details including special high frequency operating conditions are available on request. Please quote reference D4163 in your correspondence.

Mullard

GOVERNMENT AND INDUSTRIAL VALVE DIVISION

MULLARD LIMITED
Government & Industrial Valve Division
Mullard House, Torrington Place, London W.C.1

Operation for anode voltage obtained from three-phase half-wave rectifier without smoothing filter								FILAMENT CHARACTERISTICS	
TYPE	LIMITING VALUES				CONTINUOUS OPERATION				
	pa max (kW)	Va max (kV)	Ik max (A)	f max (Mc/s)	Pout (kW)	f (Mc/s)	Vtr (r.m.s.) (kV)	Vf (V)	If (A)
TY6-1250A (air-cooled)	1·3	7·0	2·0	50	4·0	50	5·1	6·3	65
TY7-6000W (water-cooled)*	6·0	7·0	2·3	55	6·0	50	5·1	12·6	33
TY8-15W (water-cooled)*	15	8·0	5·5	30	17·7	30	5·9	6·3	130
TY12-20W (water-cooled)*	20	13	6·3	30	39	30	8·9	8·0	130
TY12-50W (water-cooled)*	50	15	15	30	100	30	—	17·5	196

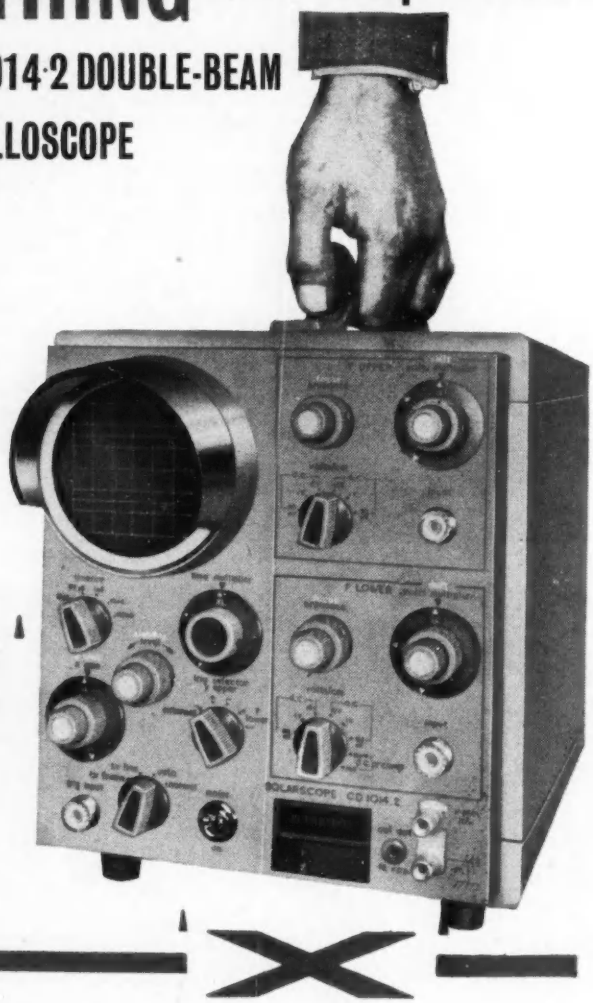
* *Also available in air-cooled versions*

MVTC 414

it has EVERYTHING and it's portable

SOLARTRON

CD 1014·2 DOUBLE-BEAM OSCILLOSCOPE



Carried around as your 'pet' instrument this versatile double-beam 'scope makes light work of any servicing or development problems.
The CD 1014·2 locks to video signals with the built-in TV sync. separators; gives bright, well defined traces at fast or slow speeds; has stabilised EHT ensuring accurate calibration independent of brightness levels; incorporates high gain pre-amplifier —in fact it has all the features that make it ideal for on-the-spot servicing and general research work anywhere in the world.

'Y' SYSTEM includes two wideband amplifiers effectively covering DC–Servo–Audio–Video–and Transient applications.
Y_1 & Y_2 bandwidths DC–5 Mc/s (-3 dB) in the 100 mV/cm–100 V/cm range.
Rise time 70 mμsecs.
1 mV/cm maximum sensitivity on Y_2 a.c. input.
Inputs can be 'floated' with respect to earth.
Input constants Main amplifiers 1 MΩ/30 pF; Y_2 preamp. 2.2 MΩ/30 pF.
Measuring accuracy to 5%.

Dual displays from a twin-gun c.r.t. 3AZP31 (P7 and P11 phosphors also available)
Calibration squarewave 0.5 V pk-pk ± 1%, at mains frequency
Only 2 valve types used, silicon rectifiers, 'C' cored mains transformer
Mains input 110/220V ± 20V, 45-66 c/s
Consumption: 75VA
Weight 22lbs

'X' SYSTEM Basic time-base range 1 cm/μsec–1cm/sec, continuously variable; accurate to 5%.
Symmetrical expansion, continuously variable and calibrated at x 1, 2 and 5.
Adequate X shift centres any portion of the trace.
'Level' and 'Stability' controls for triggering and locking the signal at any selected point on the trigger waveform.
Time-base waveform from cathode follower available at a socket, 15 V pk.
Provision for direct access to X amplifier; bandwidth DC–200 Kc/s (-3 dB); sensitivity 0.2 V/cm–2 V/cm, continuously variable.

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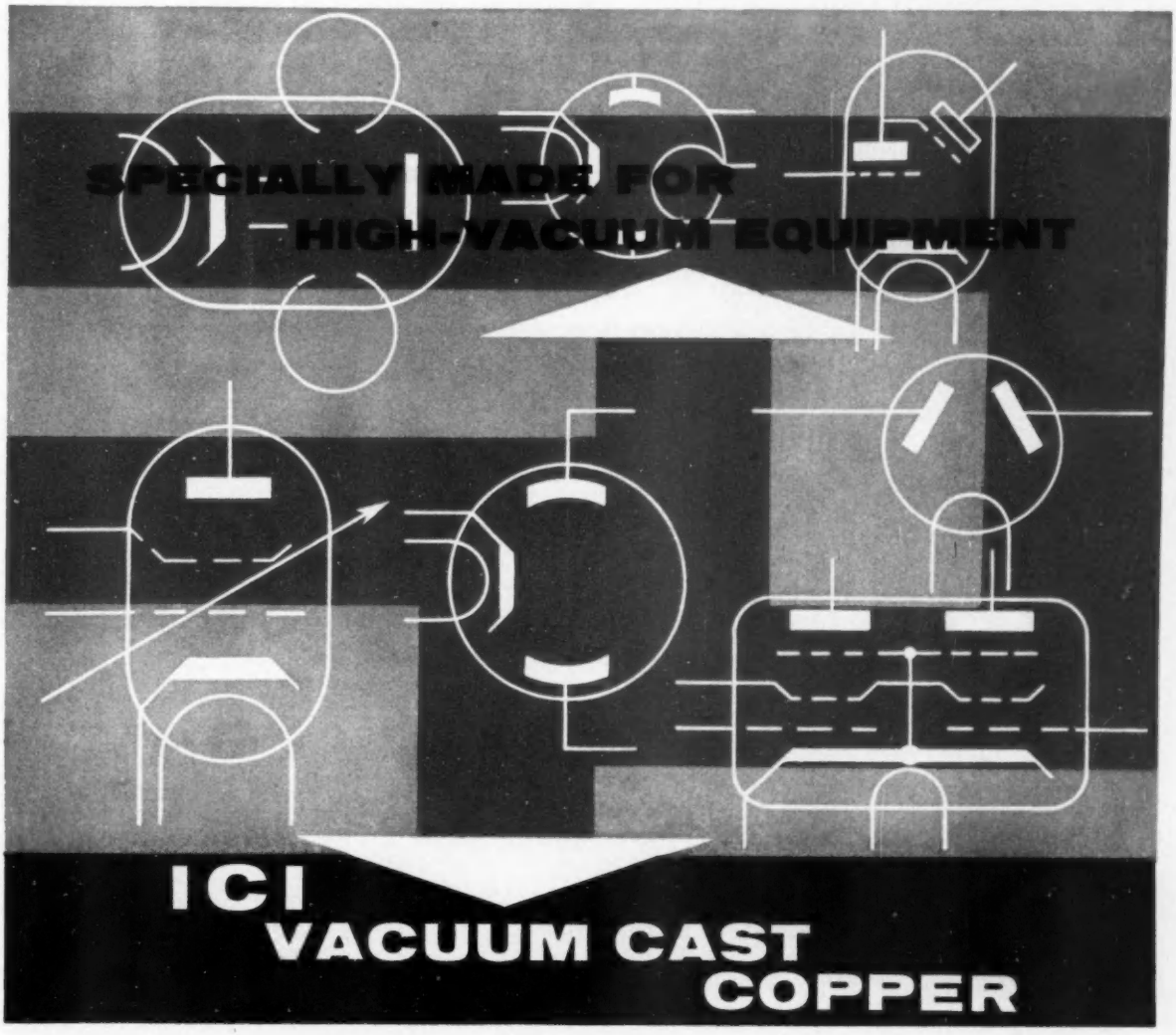

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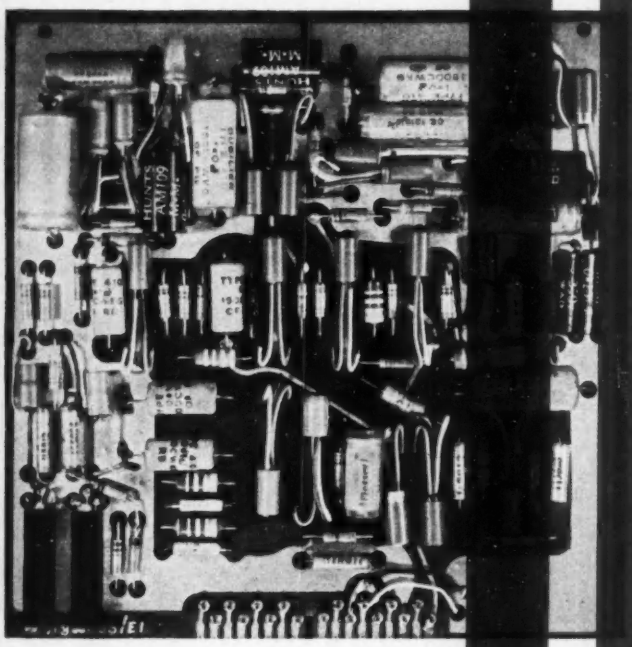
modular instruments for industrial process control and data handling



OPERATIONAL AMPLIFIER

This Operational Amplifier is built on a 7 inch x 7 inch printed wiring board for easy incorporation into other equipment. Usually it plugs in but for extra reliability it can be wired in.

The Amplifier can be used for differentiating, integrating, linearising, analogue to digital, voltage to digital and frequency to voltage conversion. It is one of the basic circuits in the Dataflex range and is used in a number of Dataflex Units.

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- **Transistor chopper for drift correction**
- **Extremely low input voltage and current drift**
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5,300 lbs

FREQUENCY RANGE
DC-7 K/s

TOTAL STROKE
0·7 ins

VG 108 MK11
VIBRATION GENERATOR

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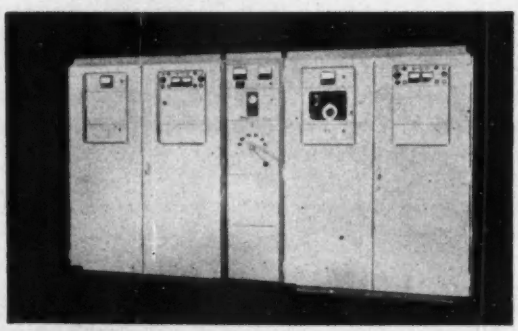

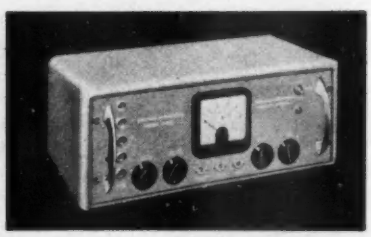

Illustrated left, is a PA 20KVA Power Amplifier; and above, the E501 'g' Control Amplifier.

*

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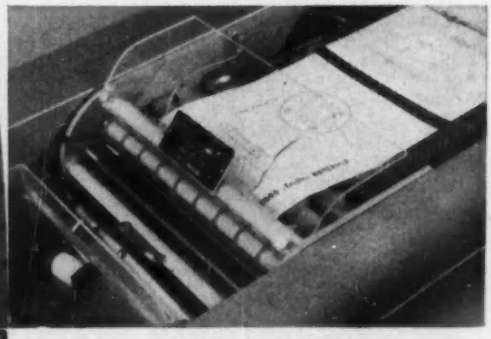

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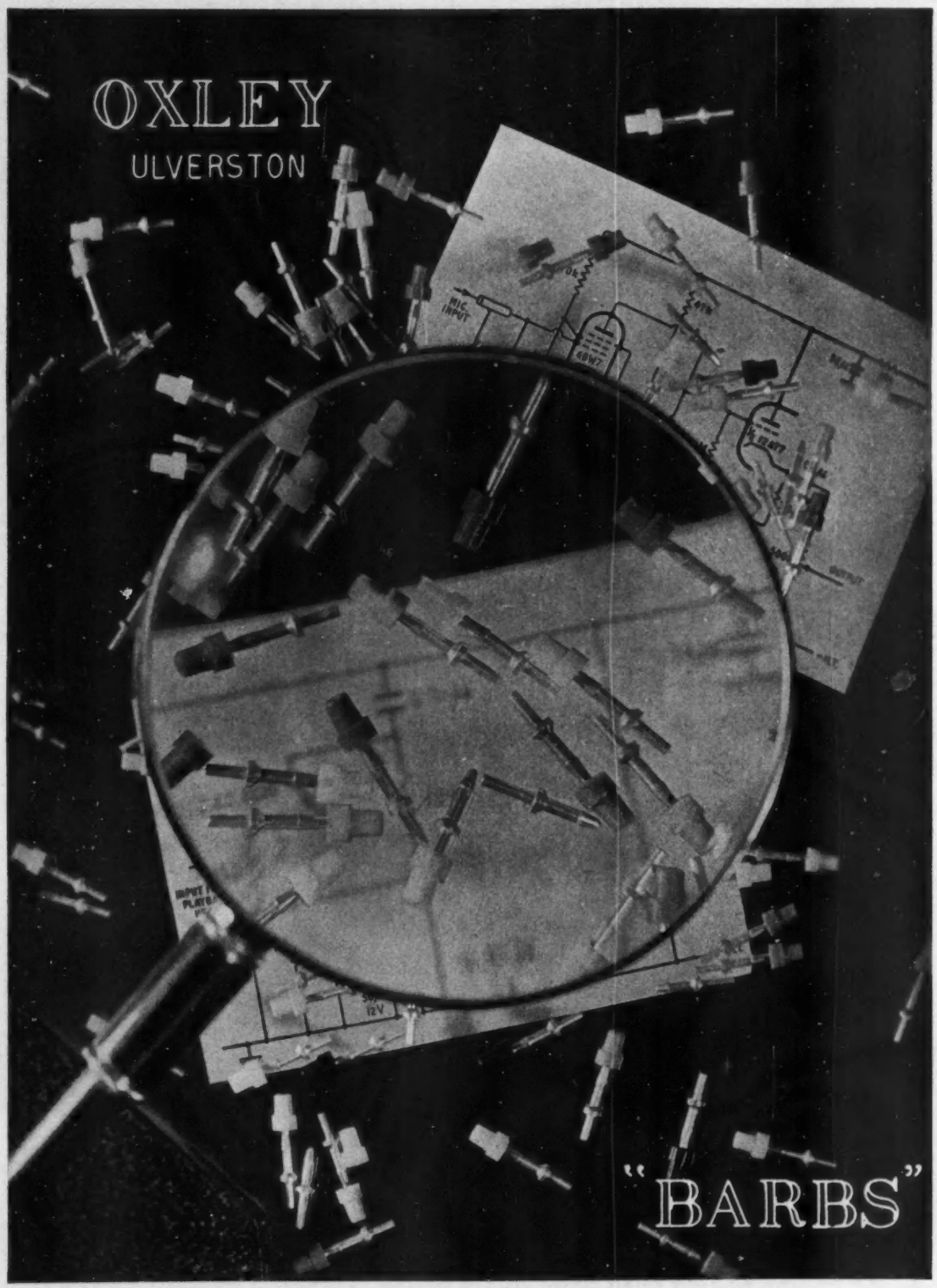

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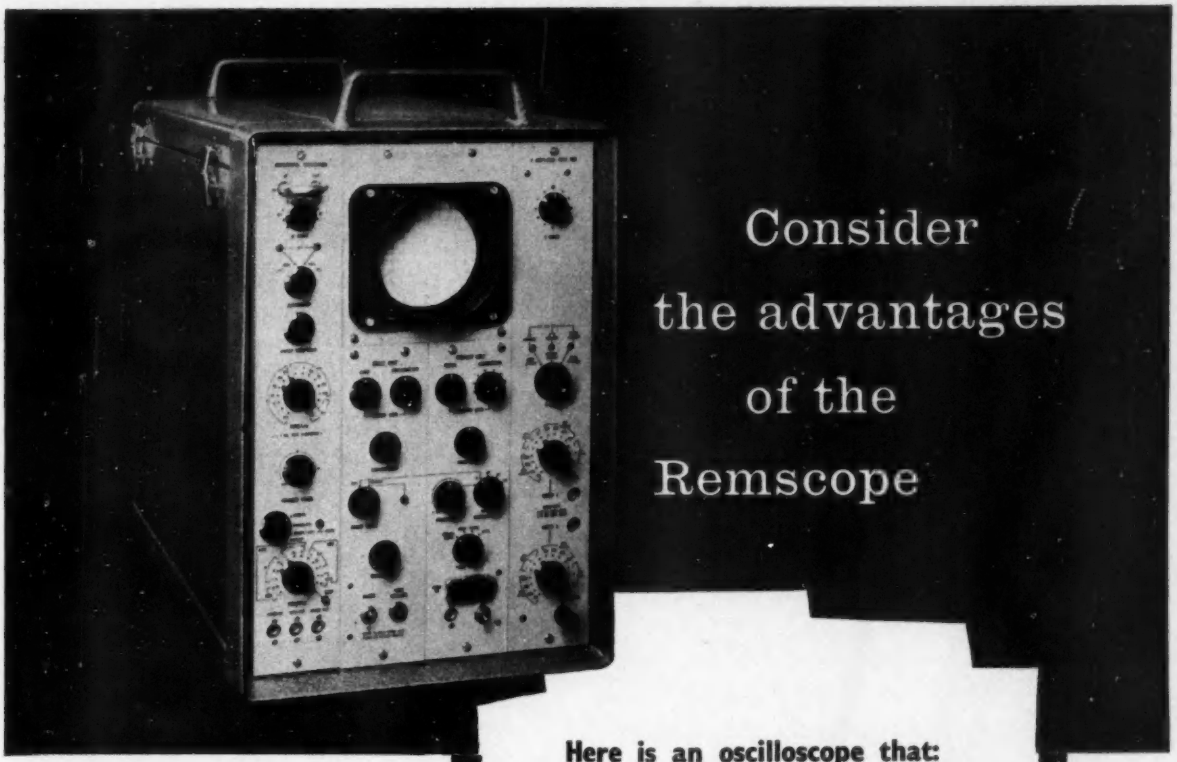

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Size: 23½ in. x 14½ in. x 24 in.
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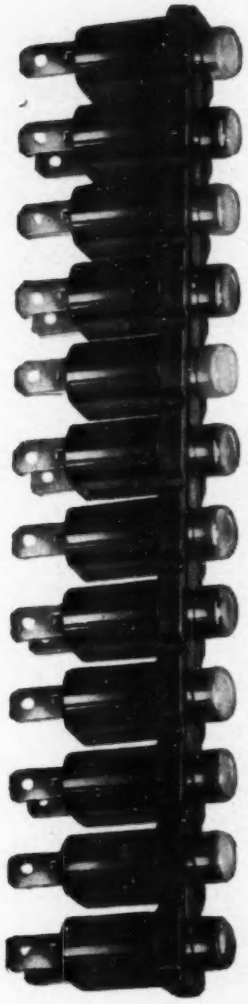

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DTV/11

The Highest Sensitivity
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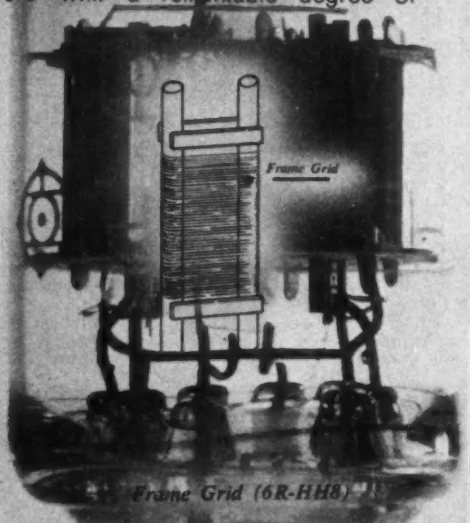
Advanced electronic research by Hitachi technicians has now resulted in the development of a superb frame grid type twin triode (6R-HH8) with excellent high gain and low noise characteristics. As a component of the tuner, the 6R-HH8 ensures an excellent picture with a remarkable degree of definition.



Frame Grid (6R-HH8)

fig. 1 Gain characteristics

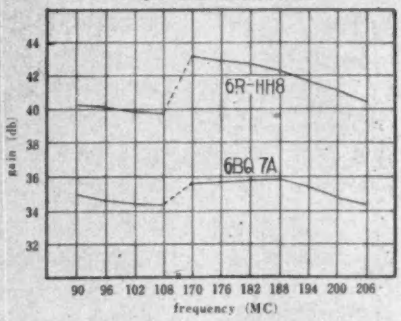
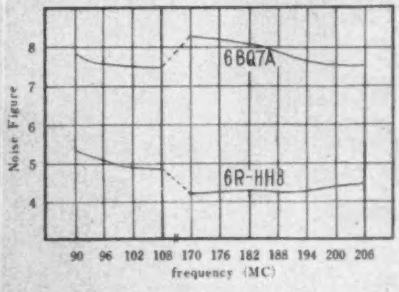
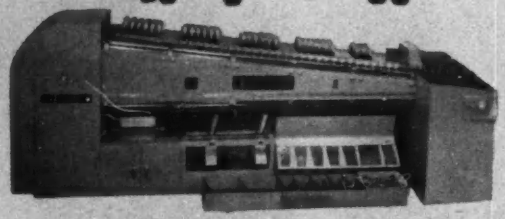


fig. 2 Noise characteristics



Hitachi also produces other receiving tubes and components for television which, when used together with the new 6R-HH8, cannot fail to earn any maker a market reputation even better than he currently enjoys.



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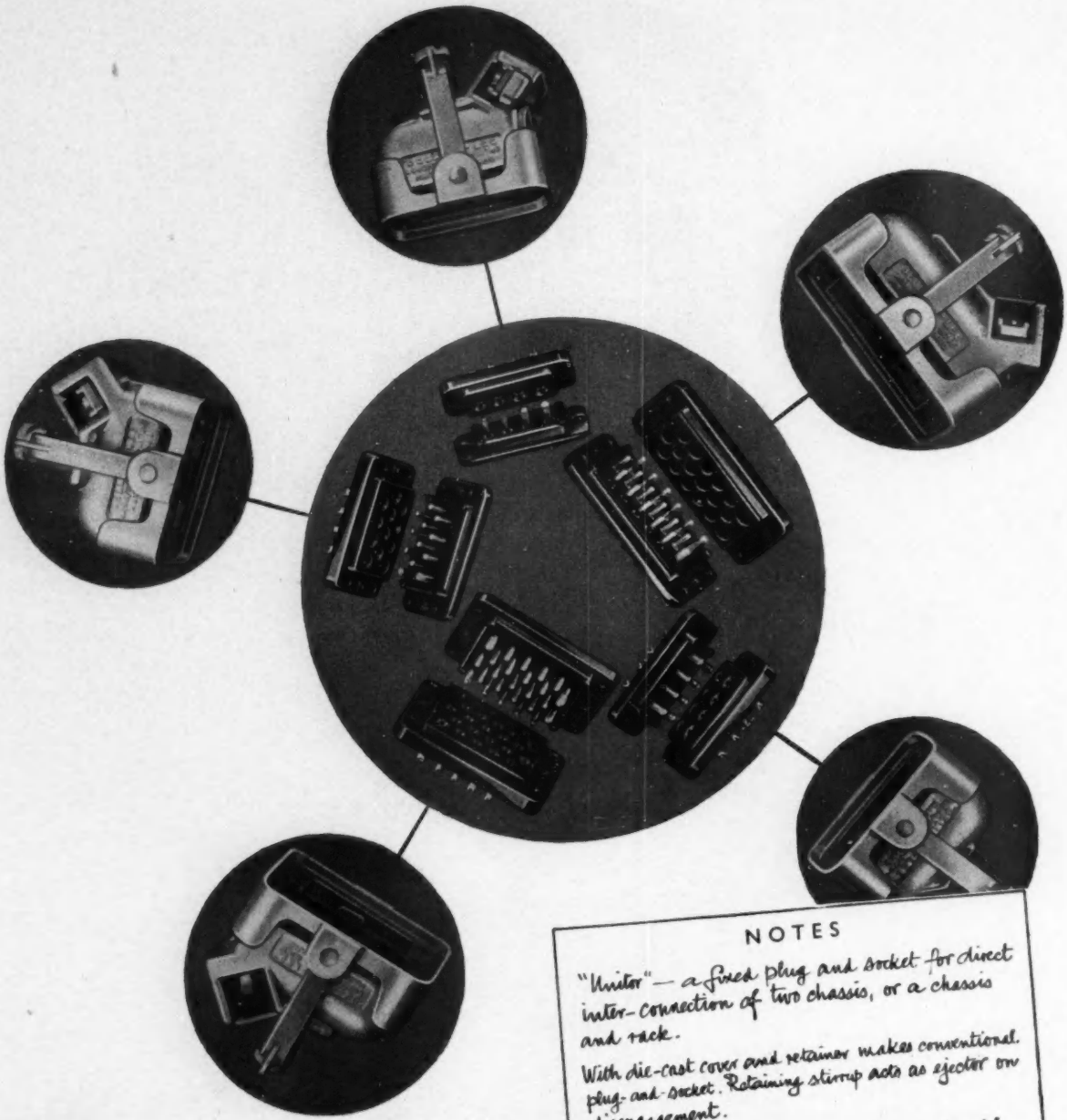

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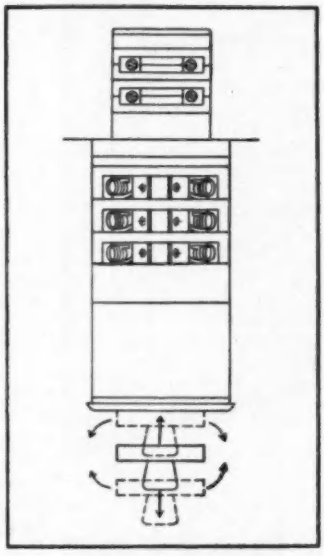

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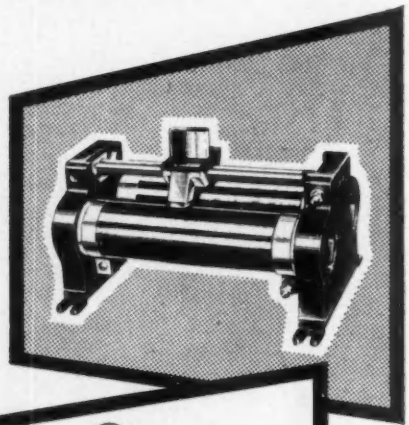

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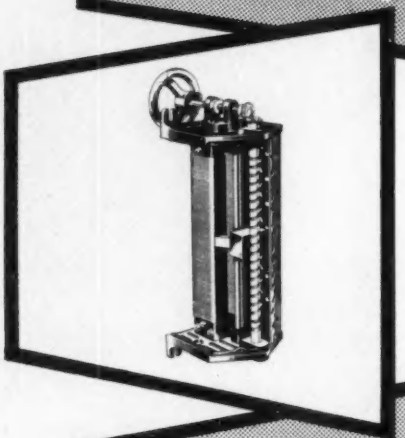

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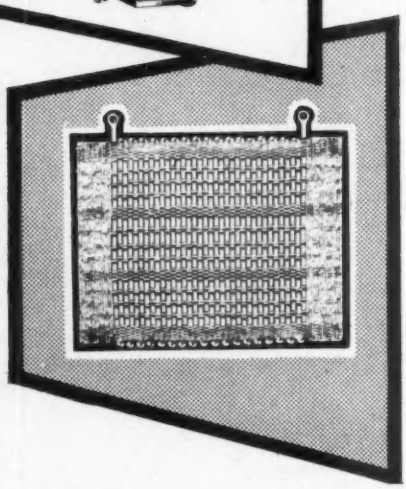

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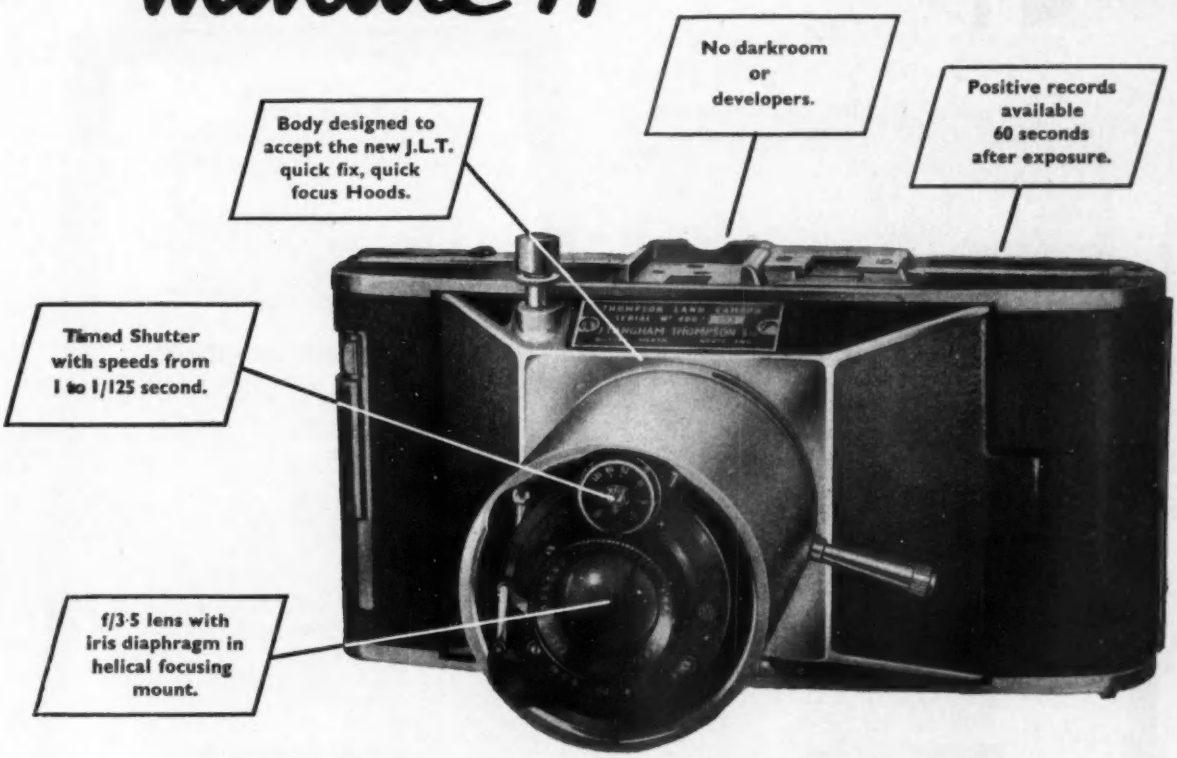
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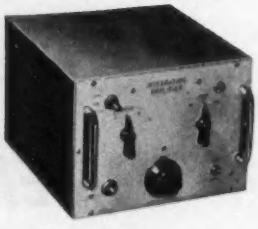

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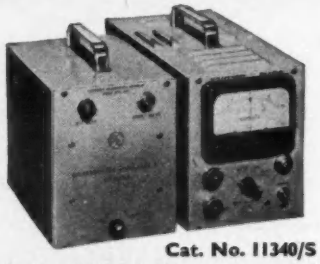

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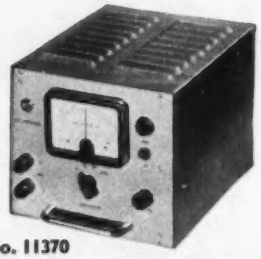
Cat. No. 11330

Galvanometer Preamplifier

Gives fast, positive indication on a standard taut-suspension galvanometer for input signals as small as 0.1 μV from a source resistance of about 100Ω.



Cat. No. 11370

D. C. Amplifier (Contact Modulator)

Low voltage amplifier for factory or laboratory. Extremely low drift and noise (≯1μV). Effective suppression of any mains frequency contamination of input signals. High output of ± 10V at currents up to 5 mA. Thoroughly reliable "chopper". Ranges ± 100 μV, 1 mV, 10 mV, 100 mV. Input resistance 3.4 k Ω.

A completely new Automatic Controller, incorporating a double electronic relay with independent setting levels, and a battery-operated High Resistance Test Set are also available. Please ask for descriptive leaflets.

W. G. PYE & CO. LTD.

Granta Works, P.O. Box 60, Cambridge, England
Tel: Cambridge 58866 (5 lines). Grams: Pye Cambridge

SCIENTIFIC PYE INSTRUMENTS

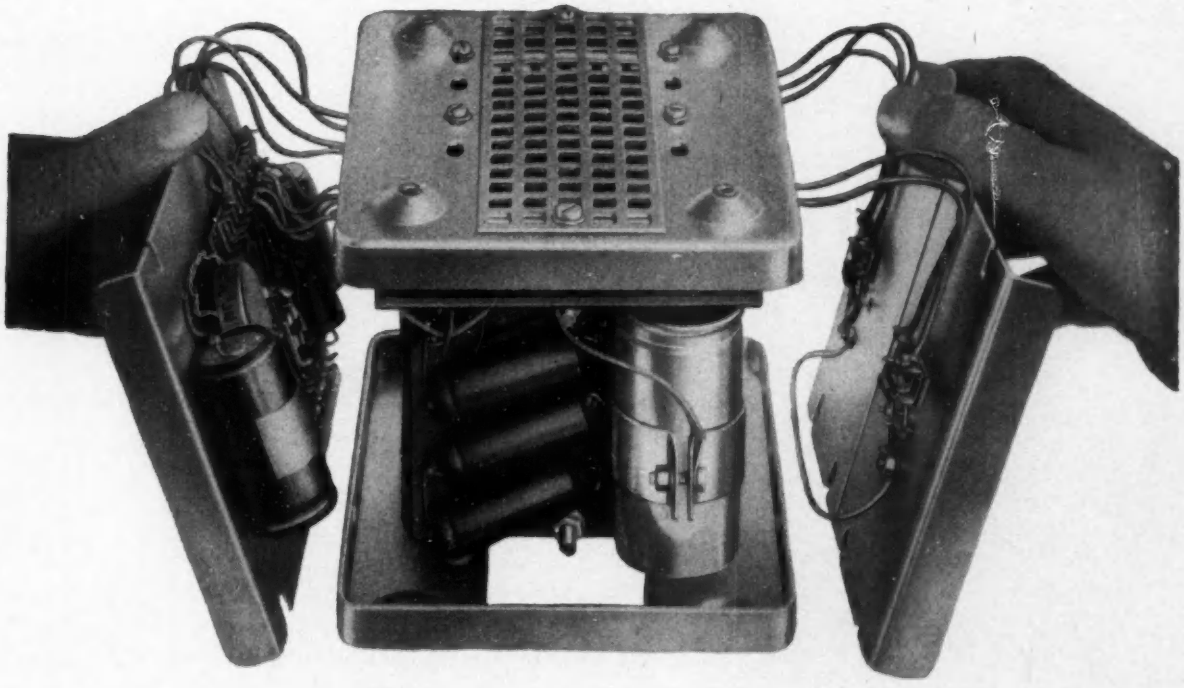
EE 31 083 *for further details*

Low in cost - Highly flexible

TRANSISTOR P.S.U.s

Here is the most economical and convenient method of obtaining low voltage power supplies to meet differing production or laboratory requirements.

Mullard Equipment Limited has produced a range of P.S.U. sub-assemblies, consisting basically of four simple units which, readily added one to another in building brick fashion, will provide power from 1 to 39 volts. And they will do this most economically. A 1 amp stabilised supply need cost only £25.



The four basic units are:—

- ✳ **1 amp Unstabilised Unit (YL. 6101)**
- ✳ **5 amp Unstabilised Unit (YL. 6102)**
- ✳ **250 mA Stabiliser and Reference Section (YL. 6103)**
- ✳ **Series Regulator Section (YL. 6104)**

Constructed for easy assembly, the basic units may be duplicated in operation for higher power applications.

These P.S.U.s are ideally suited for use in equipments and systems employing other Mullard Equipment sub-assemblies such as the well-known Norbits and Combi-Elements.

For further details please write to:

MULLARD EQUIPMENT LIMITED

Mullard House • Torrington Place • London WC1 • Tel: Langham 6633

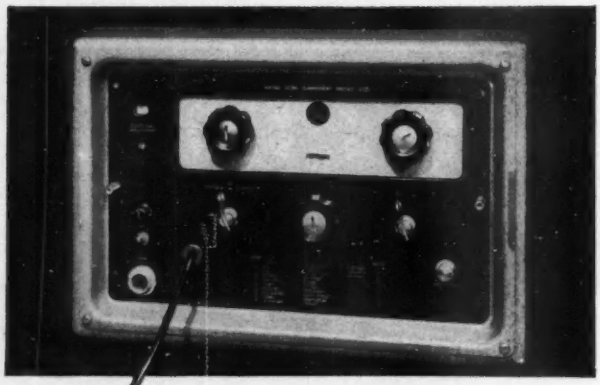
MEB 079

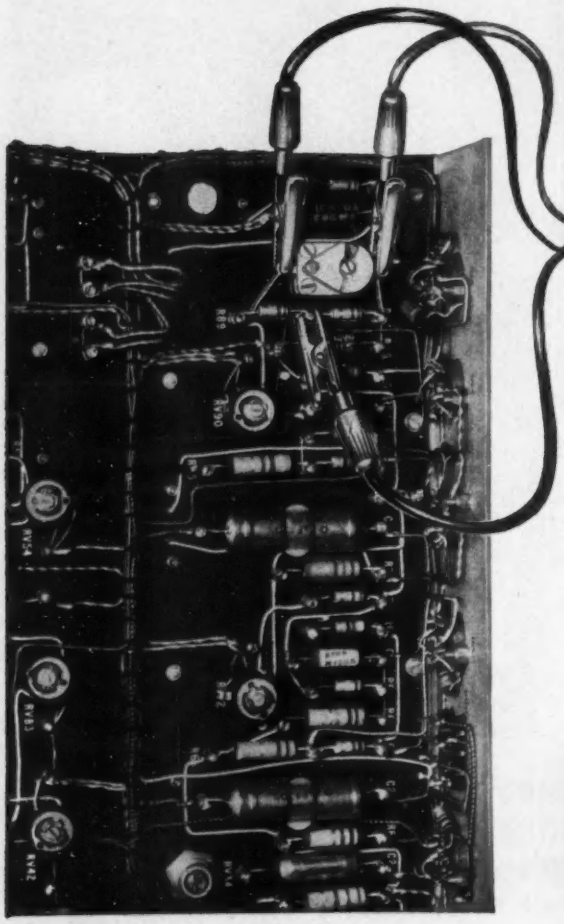
EE 31 084 *for further details*

un-soldering made obsolete

The ability to measure complex impedances over the range 1 milliohm to 1000 megohms whilst still in circuit—that is the outstanding advantage afforded by the Component Bridge B521.

Accurate to ±2%, the B521 is a transformer ratio-arm bridge of advanced design intended for the rapid, direct measurement of virtually all components and networks in research or development laboratories, in the manufacture and servicing of radio, television and electronic equipment and for a variety of industrial applications.





Employment of the transformer ratio-arm principle—affording 2, 3 or 4 terminal measurement—makes it possible to measure any arm of a delta network in the presence of the other arms. This means, in effect, that even when dealing with a highly complicated electronic chassis it is no longer necessary—as it is with a conventional Bridge—to unsolder individual components in order to ascertain their true value. This facility is particularly important at a time when the printed circuit is coming into even wider use.

Full details of this instrument and its applications are discussed in Information Service Publication AB521—please write or 'phone for a copy.

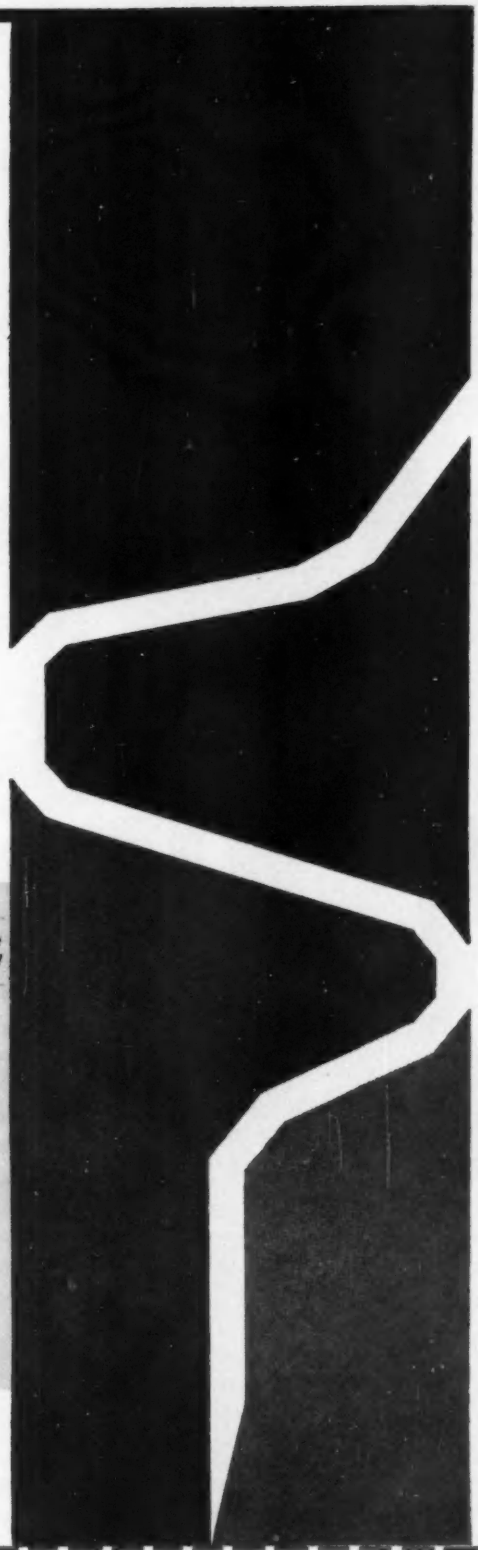
WAYNE KERR

Component Bridge B521

THE WAYNE KERR LABORATORIES LTD.
Sales and Service, 44 Coombe Road, New Malden, Surrey
Telephone: MALden 2202

WK5

specify H point contact germanium diodes



Hughes HG10 series are point contact germanium diodes with high peak inverse voltage, high back resistance and good forward characteristics. They have excellent recovery characteristics and evidence no forward current saturation within their power limitations.

Made in Glenrothes, Scotland, the Hughes range of silicon and germanium diodes are subminiature devices with extremely stable electrical and mechanical characteristics. These diodes are specially designed and constructed to meet the most exacting requirements of military or commercial applications. They are double wire ended and fusion-sealed in a subminiature one-piece glass envelope to ensure complete isolation of the active elements from damage or contamination. The small size, combined with rigidity of construction and small mass of the elements, enable them to successfully withstand physical shock and vibration.

Type No.	Continuous Ratings 25°C		Characteristics @ 25°C	
	Peak Inverse Volts	Max. Forward Current	Min. Forward Current at 1V	Max. Reverse Current at 50V
HG1001	100	45 mA	20 mA	50 μa
HG1002	100	45 mA	20 mA	100 μa
HG1003	100	45 mA	10 mA	50 μa
HG1004	100	45 mA	10 mA	100 μa
HG1005	100	45 mA	5 mA	50 μa
HG1006	100	45 mA	5 mA	100 μa
HG1007	75	45 mA	20 mA	50 μa
HG1008	75	45 mA	20 mA	100 μa
HG1009	75	45 mA	10 mA	50 μa
HG1010	75	45 mA	10 mA	100 μa
HG1011	75	45 mA	5 mA	50 μa
HG1012	75	45 mA	5 mA	100 μa

Actual Size

Qualified engineers in our Research and Development laboratories at Glenrothes are available to help with your application problems.

Home and Overseas enquiries to:

HUGHES INTERNATIONAL (U.K.) LTD

KERSHAW HOUSE, GREAT WEST ROAD, HOUNSLOW, MIDDLESEX · HOUNSLOW 5222

EE 31 086 *for further deatils*

Capacitorability

In the design and production of thoroughly reliable electrolytic capacitors, Plessey have for years held a commanding lead. To every new demand made by rapid developments in radio, television and electronic equipment Plessey can respond by bringing to bear unrivalled experience, tremendous resources and highly skilled staff. Such is the care taken to obtain impeccable standards of quality and performance, that virtually clinical conditions of manufacture are maintained in the superbly equipped laboratories and workshops. These same exacting standards are imposed throughout the comprehensive range of capacitors produced by Plessey.

Whatever the requirement **Plessey** **provides the finest component**

THE PLESSEY COMPANY LIMITED

Capacitors & Resistors Division: Kembrey Street · Swindon · Wiltshire · Tel: Swindon 6211

Overseas Sales Organisation :

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CR9

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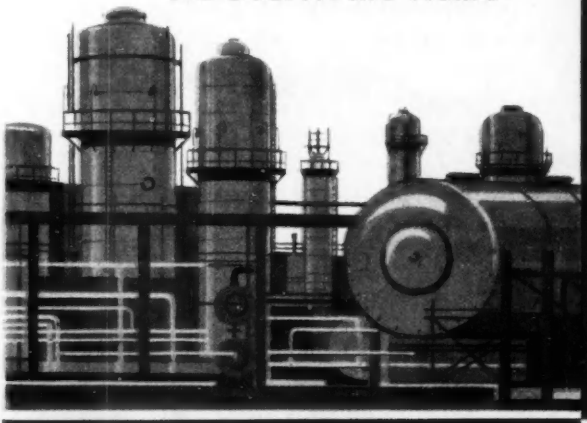
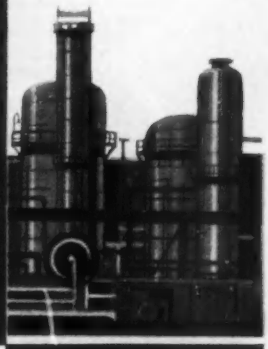
ELECTRONIC GRADE HYDROFLUORIC ACID

40% 48% & 49 ± ·25%

ANALYTICAL REAGENTS

NITRIC, HYDROCHLORIC and SULPHURIC ACIDS





also available . . .
TECHNICAL GRADES
HYDROFLUORIC ACID
FLUORIDES
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and
SILICOFLUORIDES

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Telephone: Leicester 63861

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A MEMBER OF
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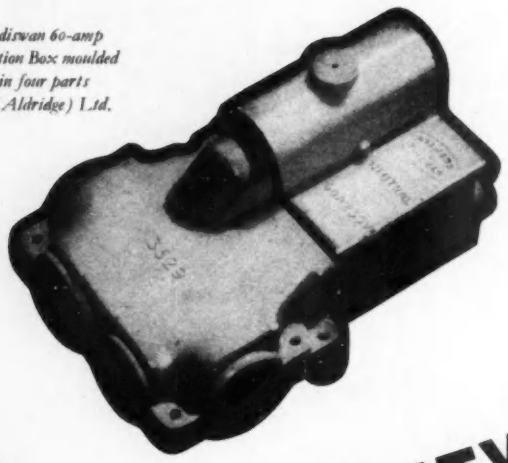
Siemens-Ediswan 60-amp Input Junction Box moulded in D M C in four parts by AEI. (Aldridge) Ltd.



DURABILITY

Good-looking grille on Morphy-Richards Fan Heater is a moulding by Crystalate (Mouldings) Ltd. in a special "thin flash" grade (L.1834) of Beetle D M C.

Wolf "Safetymaster" Power Tool. D M C mouldings by Minerva Mouldings Ltd. are ingeniously designed to provide double insulation.

Beetle Polyester D M C is equally outstanding for its electrical insulating and anti-track properties as for its high heat resistance and mechanical strength. That's why it is unbeatable for high-duty applications, of which the examples shown are typical. D M C is economical because it is fast-curing and simple to mould under low pressure in conventional compression and transfer presses. Compatibility with metals and dimensional stability are above normal for thermosetting materials.

Two glass-filled types are available: Type A for general purpose and electrical components; Type B, a self-extinguishing material. Also Type C, an economical sisal filled compound. Write for full details.

BEETLE*

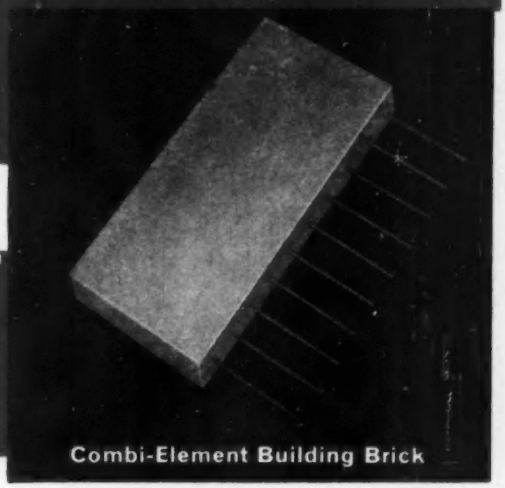
Polyester **d**ough **m**oulding **C**ompound

B.I.P. Chemicals Limited, Oldbury, Birmingham. Phone: BROadwell 2061
London Office: Haymarket House, 28 Haymarket, S.W.1 Phone TRAfalgar 3121 Telex: 33-347

EE 31 089 *for further details*

electronic sub-assemblies

FOR DIGITAL EQUIPMENT



Combi-Element Building Brick

With Combi-Element building bricks you can tackle your instrumentation problem direct from the block diagram. No need to test and prove individual circuits.

Here is a quick and convenient means of assembling 'one-off' equipments and prototypes in the laboratory.

On the assembly line, too, Combi-Elements speed up the works. In the manufacture of complete equipment—measuring units, machine tool controls, computers, etc.—compact Combi-Elements give greater flexibility to their composition, save space, and simplify stock control and ordering problems.

Combi-Element building bricks are produced in large quantities. This enables them to be supplied at low cost and ensures that a uniform high standard of reliability is achieved.

backed by comprehensive design advisory service...

Mullard Equipment Limited will be happy to discuss with you the possible uses you can make of these and other electronic sub-assemblies. A whole wealth of technical advice is freely available to you. Mullard Equipment Limited can also design and construct sub-assemblies, assemblies and systems to your individual requirements. A regular 'Sub-Assemblies Bulletin' is now being published, write to Mullard House to have your name put on the mailing list.

... for sub-assemblies, assemblies and systems

Each Combi-Element is...

A complete circuit with a new order of reliability tested under marginal conditions

Guaranteed for satisfactory working and long life

Constructed so that the inputs and outputs of different units can be directly interconnected

Hermetically sealed against humidity and other adverse conditions

The present range of units is as follows:—

Pulse Shaper

Flip-Flop

One Shot Multi-Vibrator

Twin Emitter Followers

Emitter Follower/Inverter Amplifier

Twin Inverter Amplifiers

Twin 2-Input AND Gate

Twin 3-Input AND Gate

Twin 2-Input OR Gate

Twin 3-Input OR Gate

Shift Register Flip-Flop

Pulse Logic

Power Supply Units

MULLARD EQUIPMENT LIMITED MULLARD HOUSE · TORRINGTON PLACE

LONDON W.C.1. Tel: Langham 6633

M666E

EE 31 090 *for further details*

SERVOMEX
Stabilised D.C. Power Supplies

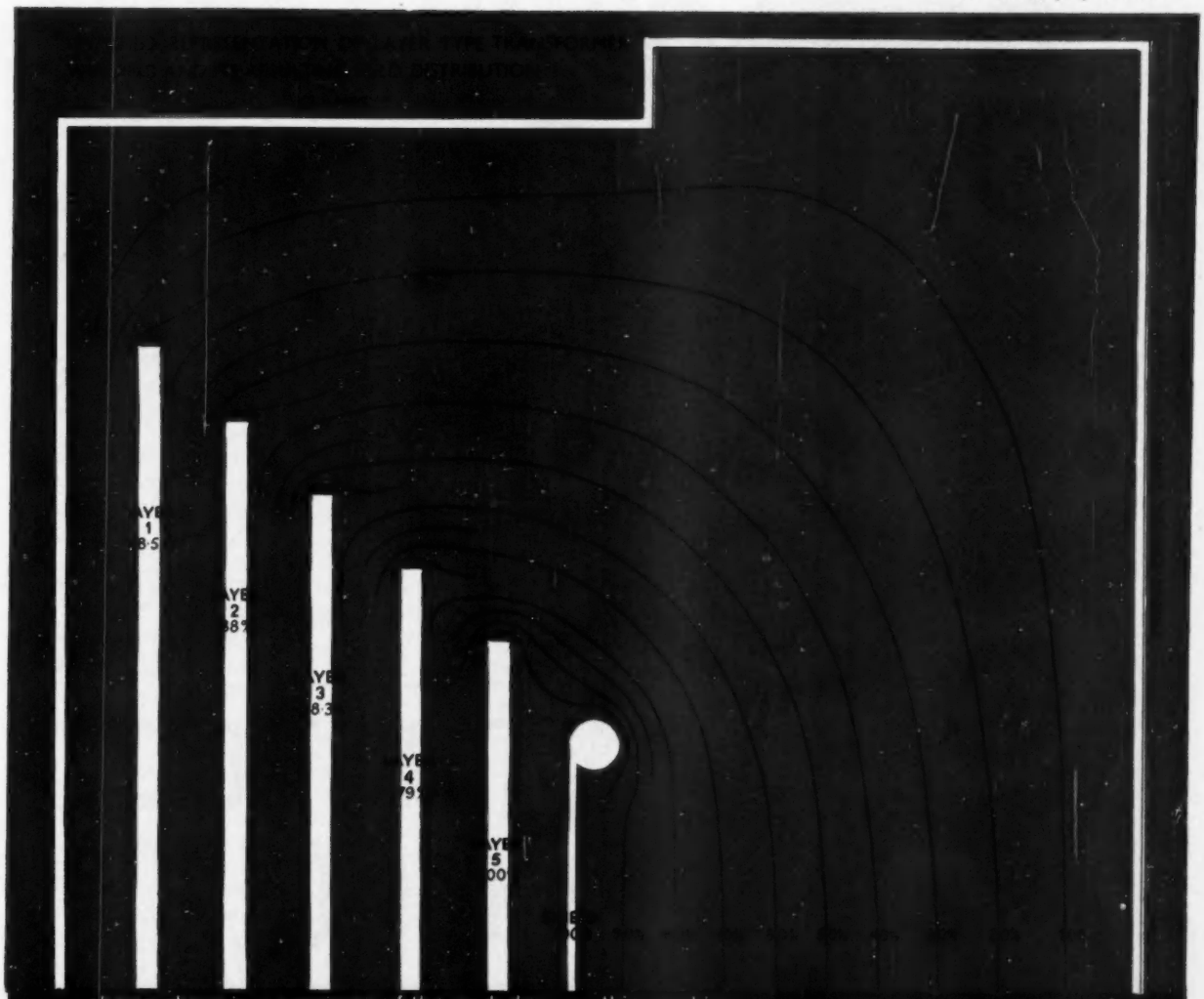
A range of relatively high power d.c. stabilisers capable of standing heavy overloads and suitable for continuous industrial use by unskilled people, and even students. Although the correcting mechanism is mechanical, the response time is shorter than many magnetic stabilisers of similar power. Small errors are fully corrected in 100 milliseconds.

The range comprises:

DC.60 24–240 volts 0-5 amps
DC.59 12–120 volts 0 to 10 amps
- Ripple at full load, about 0.1% R.M.S.
- Stability ± 0.3% of the maximum voltage of the instrument.

DC.58 6–60 volts 0 to 20 amps
DC.56 3–30 volts 0 to 40 amps
- The workmanship and the bulk of the components are to military specifications, robust, easily serviced by non-specialists, and suitable for tropical climates.

Servomex Controls Ltd., Crowborough, Sussex. Crowborough 1247



shown above is a specimen of the work done on this machine.

SERVOMEX
New Field Plotter FP92

This novel device can be applied to field problems in many branches of science and engineering; in fact, wherever the inverse square law applies. The interesting example above shows lines of electric equipotential in the insulation of a transformer. Observe that the electric stress has been magnified near the windings, because the equipotentials at these points have been plotted every 5% instead of every 10% as in most of the field. The price is £33, delivery from stock.

This field plot was supplied by the courtesy of the Transformer Development Department of Ferranti Limited, Hollinwood.

Servomex Controls Ltd., Crowborough, Sussex. Crowborough 1247

EE 31 092 *for further details*

OC200
OC200
OC200
OC200

SILICON CHARACTERISTICS AT GERMANIUM PRICE

* now costs less than any other silicon alloy transistor
* now even cheaper than many germanium types

SO NOW you can specify a quality silicon alloy transistor — in most of those instances where previously silicon semiconductors were considered too costly. What's more, there are no delivery problems. Thanks to Mullard large scale production, the OC200 is available for immediate delivery in quantity.

Already, of course, the OC200 has proved its worth in practical applications. Low bottoming voltage . . . low noise figure . . . unusually wide temperature range. The OC200 has all the attributes you could wish for in a general purpose transistor. It is suitable for use at low and high temperatures in switchgear and a wide variety of industrial equipment. And now that price is no problem — the scope of the OC200 grows wider still. If you would like further details simply write to the address below.

Minimum operating ambient temperature	(°C)	− 50
Maximum junction temperature	(°C)	+ 150
Abridged data (at Tambient 25°C)		
V_{cb} max.	(V)	− 25
V_{ce} (cut-off) max.	(V)	− 25
V_{ce} (I_c=50mA) max.	(V)	− 20
I_c (pk) max.	(mA)	50
I_c max.	(mA)	50
α^1 (f=1kc/s) spread		15 to 60
V_{ce} (I_c=7mA, I_b=1mA)	(mV)	− 130
r_{bb}^1 (V_{ce}= −6V, I_c=1mA)	(Ω)	125

Mullard

semiconductors for industry

MULLARD LIMITED
Semiconductor Division
Mullard House · Torrington Place
London WC1 · Tel: LANgham 6633

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MIS 28

EE 31 093 *for further details*

AUTRONEX
Acid Gold

A Hard Bright Gold for the most exacting industrial applications — a mildly acid solution—plating at room temperature with absolutely no free cyanide.

Ideal process for semi-conductor devices with electronic equipment—ranging from ballistic missiles to office data processing machinery.

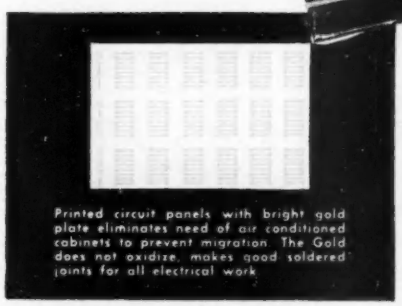
Newest and fastest computor systems for business and scientific use, utilise printed circuit boards plated with AUTRONEX Acid Gold.

Some of the advantages are:—

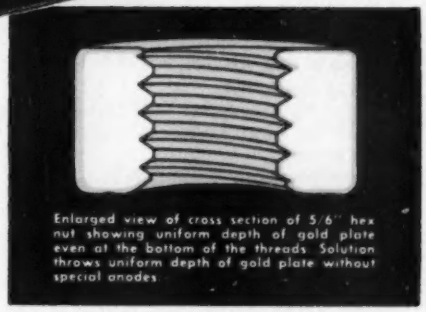
1. **Harder and more wear-resistant surfaces.**
2. **Elimination of gold strike.**
3. **Promotion of higher bond strength of circuit to dielectric base material (no damage to adhesive layer).**
4. **Elimination of circuit lifting or rejects on boards plated after etching.**

Obtain details and have samples processed in our Pilot Plant

Sel-Rex



Printed circuit panels with bright gold plate eliminates need of air conditioned cabinets to prevent migration. The Gold does not oxidize, makes good soldered joints for all electrical work



Enlarged view of cross section of 5/6" hex nut showing uniform depth of gold plate even at the bottom of the threads. Solution throws uniform depth of gold plate without special anodes

M. L. ALKAN LTD. STONEFIELD WAY · VICTORIA ROAD RUISLIP · MIDDLESEX
'Phone: VIKING 3301 (4 lines)

Offices in **BIRMINGHAM · BRISTOL · BURNLEY**

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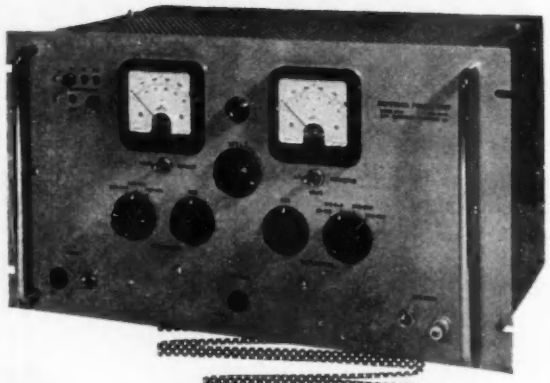
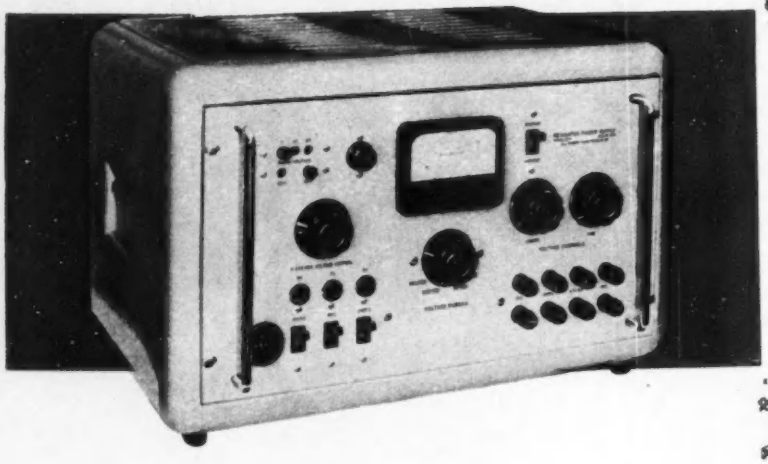
STABILISED POWER SUPPLIES



MODEL 2763
LOW VOLTAGE KLYSTRON SUPPLY
Resonator Supply 250 V — 400 V. 0-50 mA.
Reflector Supply 50 V — 400 V. 0-50 microamps.
L.T. Supply 5.5 V — 6.5 V. D.C. 0-1 Amp.
Aux. Supply for associated circuitry 400 V. 0-20 mA.
Stability better than 0.2% on H.T. lines for input variations ±10%.
Ripple less than 2 mV R.M.S.
PRICE £155 ex-works.



MODEL 508
0 — 500 V. D.C. 350 mA.
6.3 V. 10 Amps. A.C.
Neg. 250 V. 25 mA.
Stability of D.C. Outputs better than ±0.1% for input variations ±10%, and no load to full load current.
Ripple less than 3 mV R.M.S.
PRICE £98 ex-works.

MODEL 3798
0 — 50 V. D.C. 100 mA.
6.3 V. 5 Amps. A.C.
Maximum variation of D.C. Output Voltage less than 50 mV for input variations ±10%, and no load to full load current.
Ripple less than 1 mV R.M.S.
PRICE £60 ex-works.

ELECTRONIC INDUSTRIES LIMITED

CHERTSEY ROAD
BYFLEET · SURREY

PHONE BYFLEET 4911/2/3/4
GRAMS APTRAN BYFLEET

EE 31 095 *for further details*

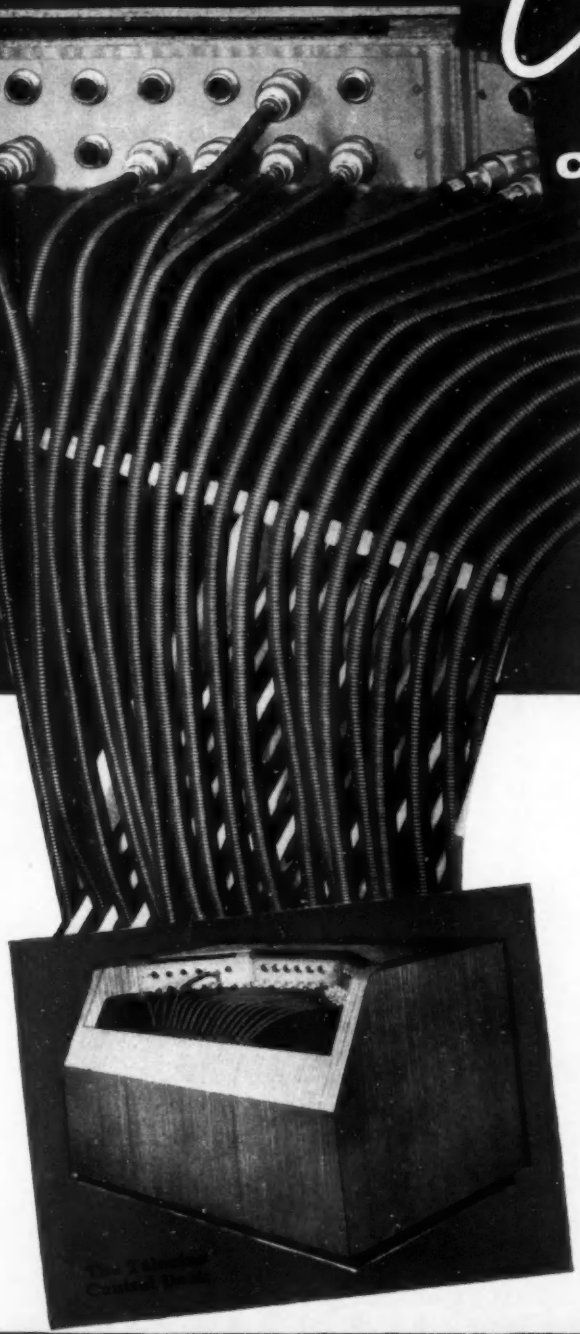
B.B.C. TV Engineers use—

Conflex

Regd. Trade Mark

CONDUIT SYSTEM

—in the New Television Centre, London



The use of Conflex conduit system on the Telecine Routing Desk at the B.B.C.'s new Television Centre is a completely new approach to installations of this nature. Many troubles that are normally associated with circuit changing are completely eliminated.

Advantages of this system are many and include:—

- A high degree of flexibility—no metal fatigue.
- Terminations that fit British and American connecters, junction boxes, etc.
- Eliminations of special cable lays, moulded harnesses and problems involved in encapsulation.
- Simplification of connecter wiring and easier conductor changes.
- *In situ* assembly that requires no special tools.
- Provision for double-screening on R.F. circuits.

* *Write for full technical details.*

SUPERFLEXIT LTD · BOROUGHHAM AVE · SLOUGH · BUCKS

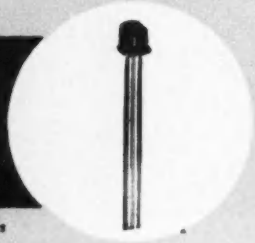
Only Transitron offers

Here is another dramatic advance

DIFFUSED MESA TRANSISTORS FOR EVERY POWER RANGE!

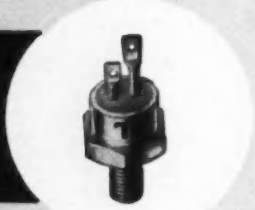
...WITH ADVANCED PACKAGES, HIGH VOLTAGES, HIGH CUT-OFF FREQUENCIES, LOW R_{CS} AND BETA LINEARITY

SMALL SIGNAL TRANSISTORS



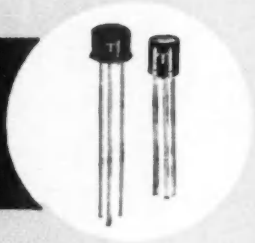
For low level switching and amplification. Replaces 2N332-2N338 with higher cut-off frequencies, lower Rcs, smaller sized TO-18 package, higher voltages, and greater reliability.
Write for bulletin TE-1353T/-1, -2, -3

INTERMEDIATE POWER TRANSISTORS



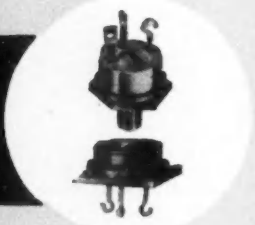
For power output stages, high power transistor drivers, and servo amplifiers — replaces 2N1047-50 and 2N1483-86 — offering low Rcs, good Beta linearity and voltage ratings to 120V.
Write for bulletin TE-1355S

MEDIUM POWER TRANSISTORS



To replace 2N339-343, with improved high frequency characteristics, good Beta linearity, low Rcs, higher voltage ratings (to 125 volts) and greater power dissipation.
Write for bulletin TE-1355J-1 & TE-1355E-2

HIGH POWER TRANSISTORS



For regulated power supplies and converter applications — replaces 2N1015-16, 2N1487-90 — with low Rcs (typical .8 ohms) higher cut-off frequencies, and lower leakage currents.
Write for bulletin TE-1355R

With these new transistors, Transitron offers improved performance and outstanding features in all power ratings from 100 microamps to 5 amps. Each functions in a wide operating range—permitting use of fewer types and simplifying equipment manufacture. All provide the ruggedness and reliability of mesa silicon construction and have high minimum switchback voltages guaranteed by specifications.

tomorrow's solutions today!

Research in depth—a new concept of applied technology—keeps Transitron not merely in the lead, technically speaking, but always at least one step ahead of the evergrowing demands of industry. It produces a constant flow of better and even more efficient materials. This, in turn, enables the Transitron Applications Laboratory in Europe to design circuits that answer any customer's specific problems.

Transitron now offers the widest range of high quality silicon semi-conductors available—with a service that ensures prompt and speedy delivery wherever you are in Europe.

Readily available from stock are many transistors including:

SMALL SIGNAL

Reference	
American	British
2N332	2S001
2N333	2S002
2N334	2S003
2N335	2S004
2N338	2S005
SN337	2S014

MEDIUM POWER

Reference	
American	British
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2N498	2S018
2N656	2S019
2N657	2S020

HIGH POWER

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TRANSFER FUNCTION ANALYSER (T.F.A.)
AND
REFERENCE RESOLVER (JX 746)

The Solartron T.F.A. and Reference Resolver JX 746 combination is unique in that it provides the required response of a system in a form suitable for the direct plotting of Nyquist and Bode diagrams.
The JX 746 extends even further the versatility of the already world famous Solartron T.F.A. and provides a digital display of phase angle.
The basic principles of this new technique in dynamic analysis are best explained by reference to the following experimental procedures.

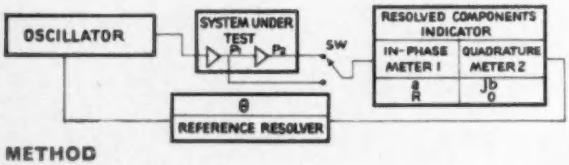
I To plot the Frequency Response of a given system over the range 0.1 c/s — 1 Kc/s in Nyquist and Bode form.

II To plot Amplitude and Phase Difference between two elements within the loop.

APPARATUS

1. Oscillator (OS 103.2)
2. Resolved Components Indicator (VP 253.2)
3. Reference Resolver (JX 746)

LAYOUT



METHOD

I Overall Frequency Response (at P_2)

1st step:

Feed system under test with accurate frequencies over 0.1 c/s to 1 kc/s (Oscillator OS 103.2)

2nd step:

Observe in-phase and quadrature components 'a' and 'jb' shown on Meters 1 and 2 of the Resolved Components Indicator VP 253.2. (see fig. 1)

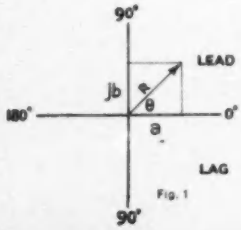


Fig. 1

3rd step:

By means of Reference Resolver (JX 746) rotate reference axes of the Resolved Components Indicator until the quadrature meter reading is zero. (see fig. 2).

4th step:

Note R = reading on Reference Meter 1 and ⊖ = digital reading on JX 746 Plot on Nyquist and Bode diagrams.

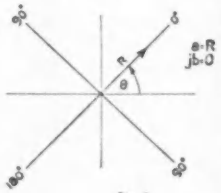
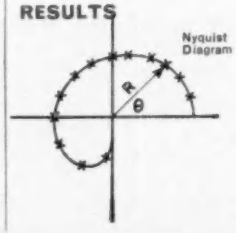


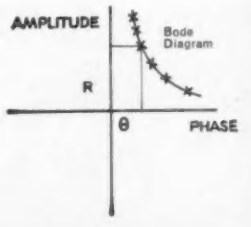
Fig. 2

II Amplitude and Phase Comparison between two points in the system (P_1 and P_2).

Having already resolved P_2 into R and ⊖ form, switch Resolved Components Indicator to P_1 and repeat the 3rd step.
Note differences in Amplitude and Phase on Reference Meter 1 and JX 746 respectively.

RESULTS





The ease of operation and high measuring accuracy of Solartron T.F.A. and JX 746 are unsurpassed in the field of dynamic analysis. These are precision instruments for determining the behaviour of—

Electrical, Mechanical and Hydraulic Servo systems —Amplifiers — Networks — Self Regulating Systems—complete Servomechanisms and Regulators —Automatic Process Control Equipment—etc— under all operating conditions.

The Solartron T.F.A. comprises
the L.F. Decade Oscillator (OS 103.2)
and the Resolved Components Indicator (VP 253.2)

RESOLVED COMPONENTS INDICATOR VP 253.2

(Frequency coverage 0.5 c/s — 1 kc/s)

This is an L.F. Valve Voltmeter with two special 6" diameter meters indicating in-phase and quadrature components of the signal voltage with respect to a reference voltage of the same frequency.
Spurious noise and harmonics are cancelled out in the unique measuring method employed in this instrument. An amplifier overload indicator ensures that no false readings are taken on the meters, which are themselves protected against overload.

THE REFERENCE RESOLVER JX 746

(Frequency coverage DC — 1 kc/s)

Specially designed for use with the Solartron T.F.A., enables the transfer information to be expressed directly in terms of amplitude and phase. The phase angle is displayed by three digital indicators.

L.F. DECADE OSCILLATOR OS 103.2

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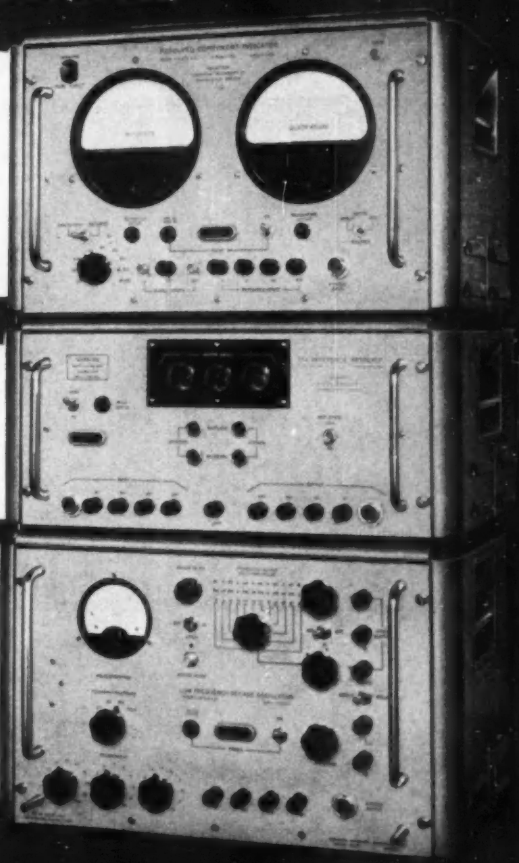
A square-wave output is also available, covering the same frequency range and of continuously variable amplitude up to 17 V pk-pk.



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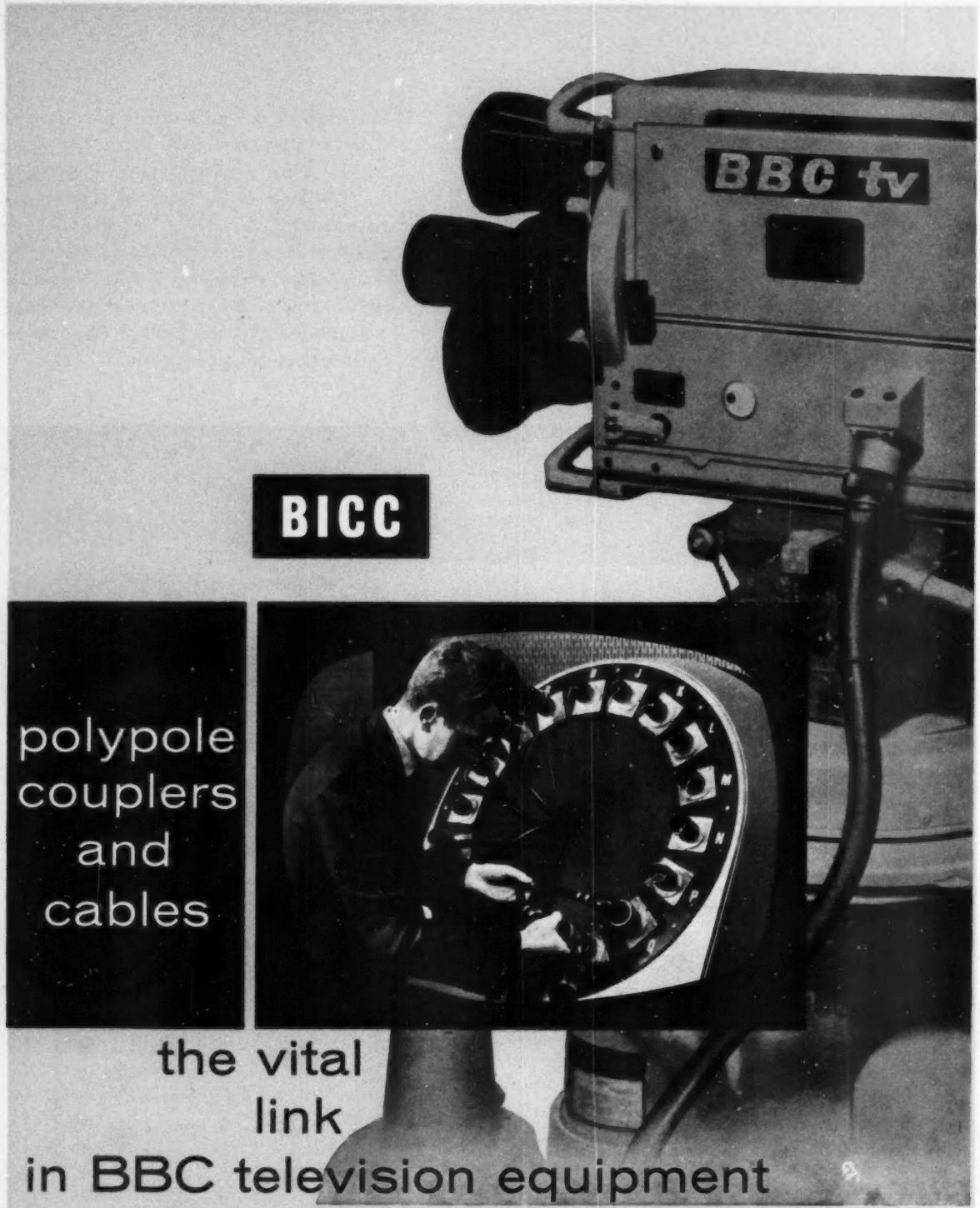

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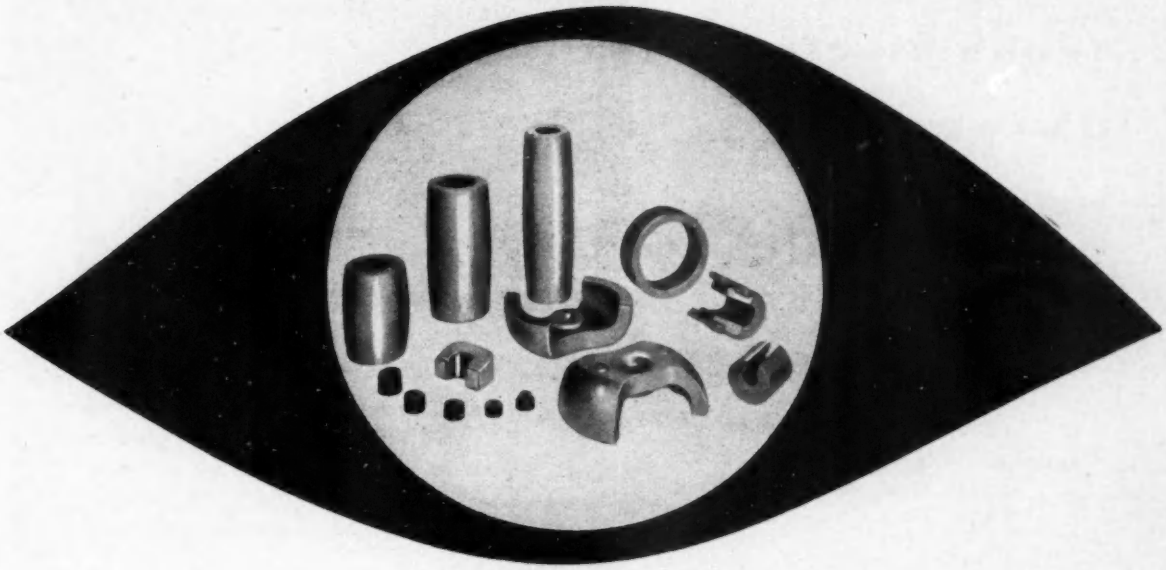

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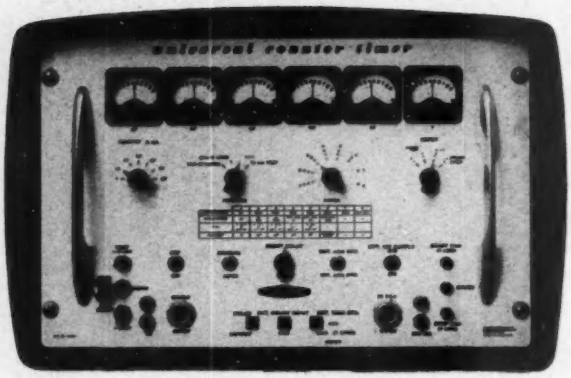

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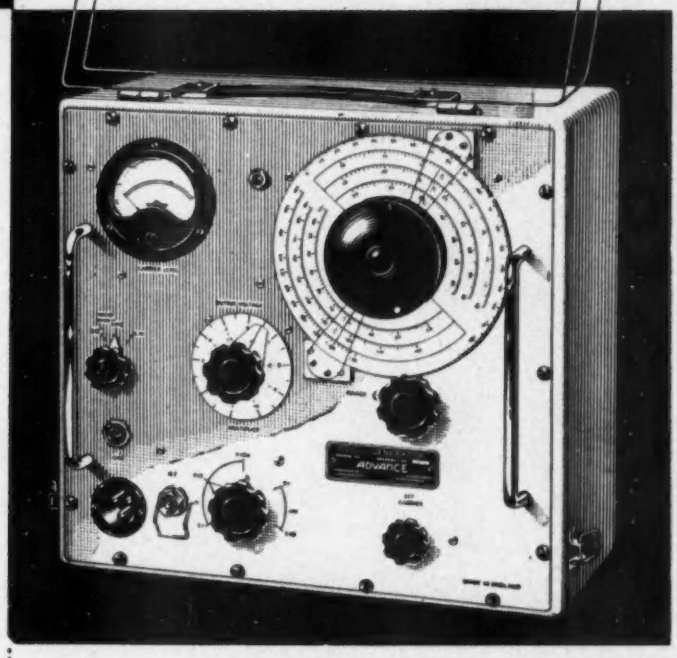
The V.H.F. TYPE DI/D SIGNAL GENERATOR



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Both the D1/D and the D1P/2 are now available with an output impedance of 50 ohms.

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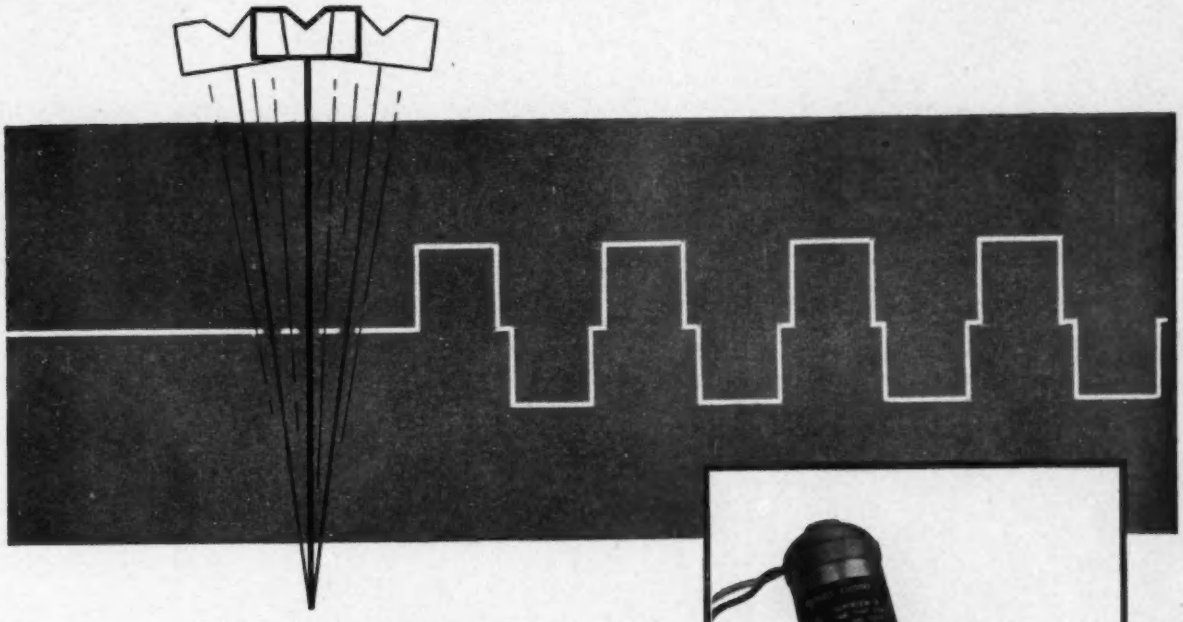

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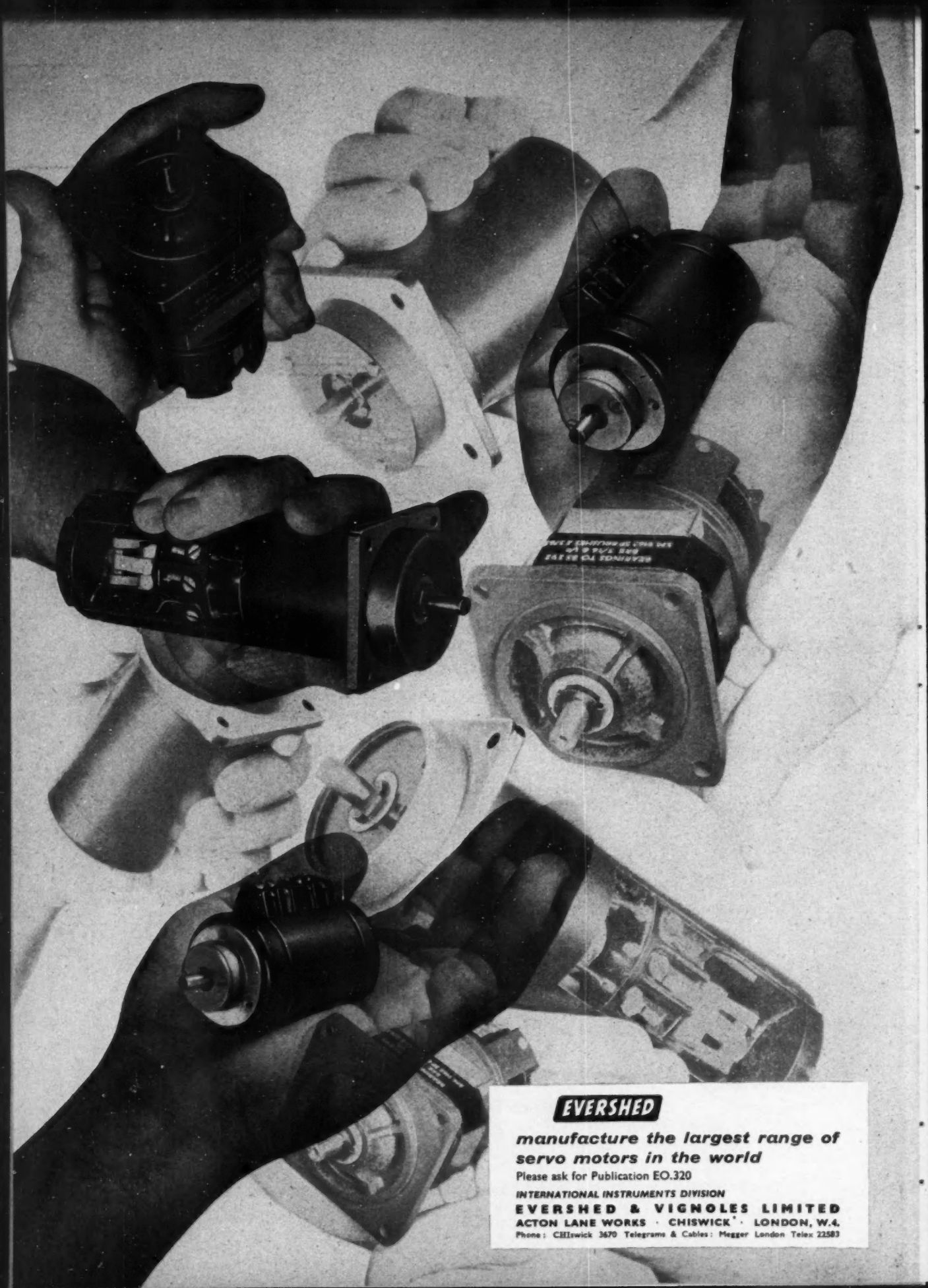

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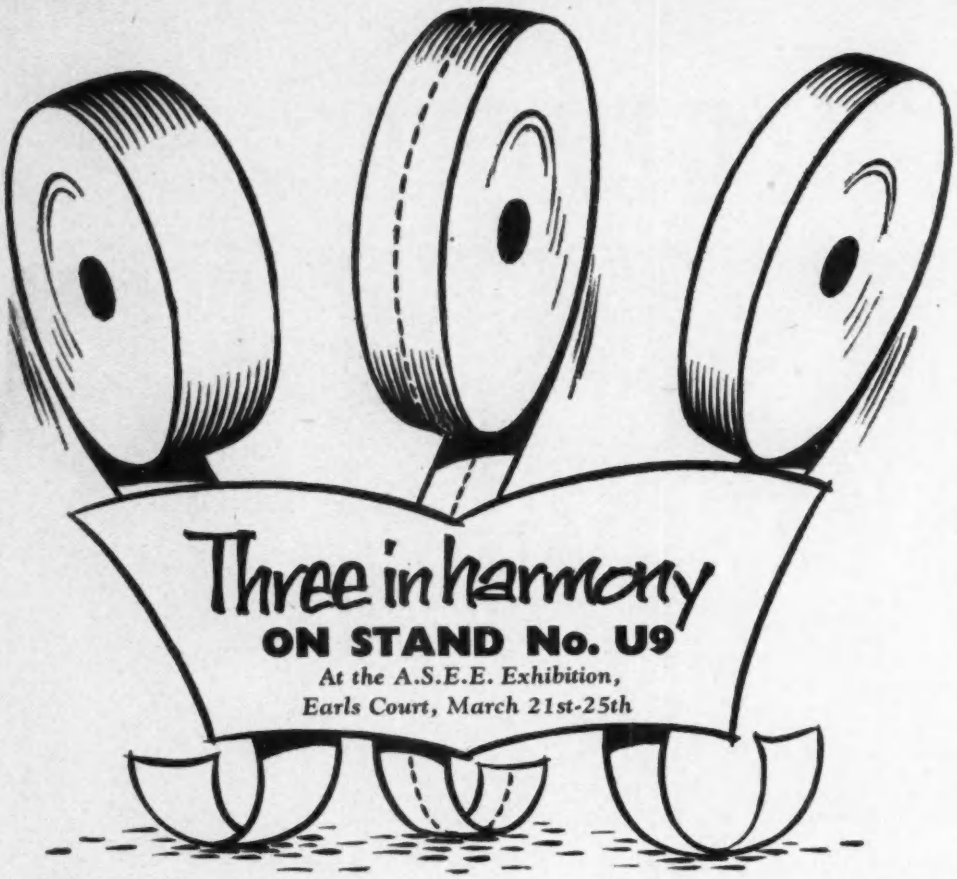

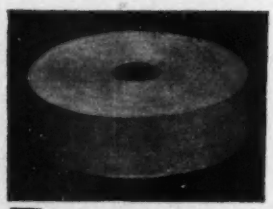

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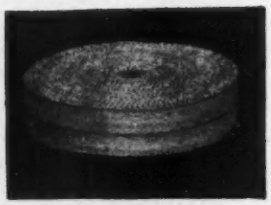
"Duraglas" Glass-fibre Tapes have many applications within the electrical insulation field such as conductor insulation, coil wrappings, core bindings, mechanical reinforcements, cable wrappings, and heat resistant protective coverings.



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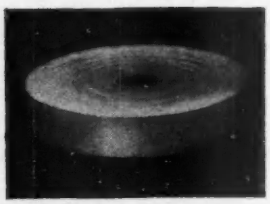

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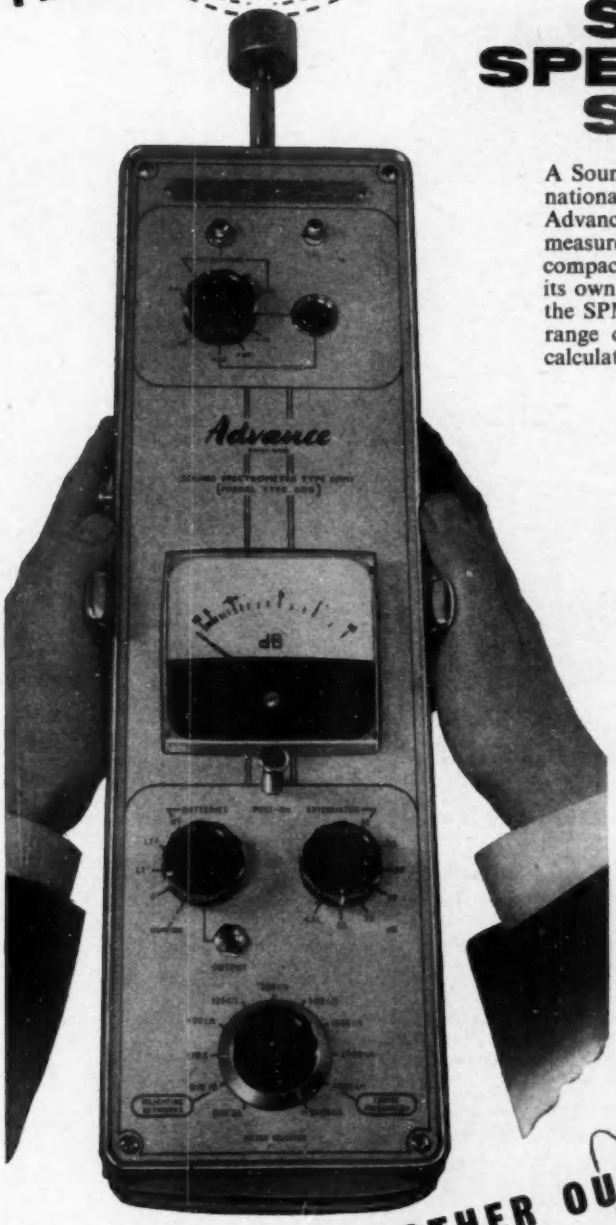

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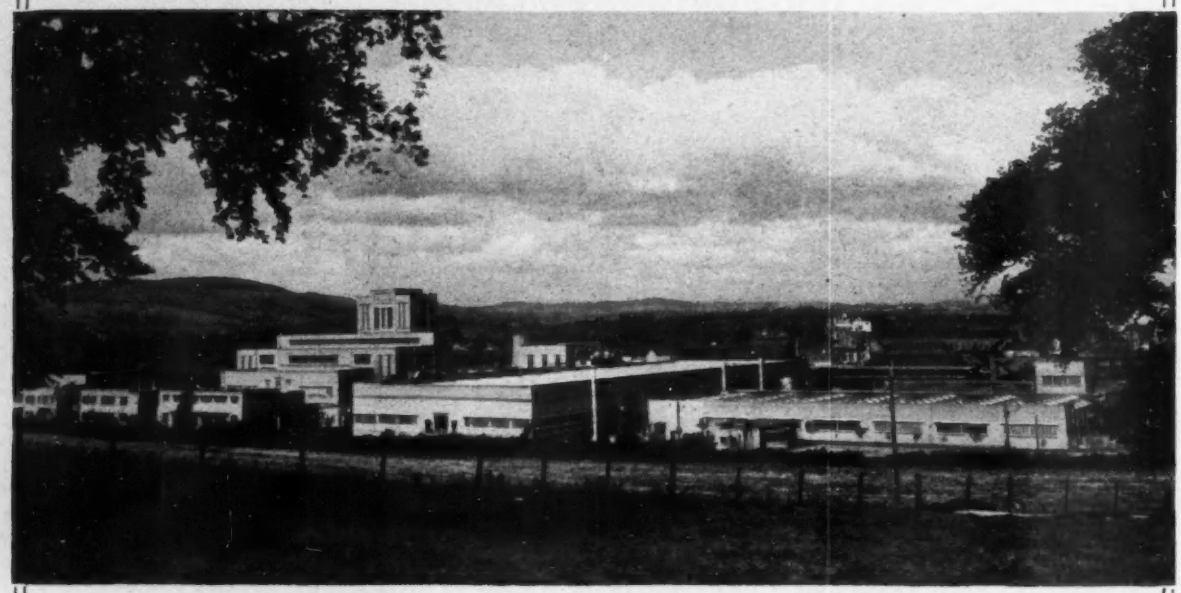
More 'Melinex' in 1961



I.C.I. build new plant to produce 2,000 tons of 'Melinex' film per year

IN JANUARY 1961, a new 'Melinex' polyester film plant will start production at Dumfries with a rated capacity of 2,000 tons/year. I.C.I., who are the sole manufacturers of polyester film in this country, have been selling 'Melinex' for some years. The demand has increased rapidly and I.C.I. have been allowing imports of American and Continental film to supplement their limited production. The new plant will remove the necessity for such imports.

More and more firms are appreciating the outstanding properties of 'Melinex' film. Its unusual clarity and strength (both mechanical and electrical) combined with its great dimensional stability and resistance to heat and chemical action, are improving a very wide range of products throughout industry.

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The Food Industry—for improving the sales appeal of goods and for 'boilable' packs.

The range of uses for this versatile film will widen considerably in 1961. If you would like further information or wish to discuss a possible application for 'Melinex' film, please write to I.C.I. Their Technical Service staff will be pleased to give advice and technical assistance.

'Melinex'

'Melinex' is the registered trade mark for the polyethylene terephthalate film manufactured by I.C.I.

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6. LOW-CAPACITANCE BRIDGE Type TF 1342. A 3-terminal transformer ratio-arm bridge for high-discrimination measurement of capacitance from 1,111$\mu\mu$F down to 0.002$\mu\mu$F, with 0.2% accuracy. Shunt resistance range:1 to 1,000MΩ. Built-in oscillator and detector operate at 1,000 c/s.

7. R.F. IMPEDANCE BRIDGE Type OA 199A/2. Precision-built unity-ratio bridge for the measurement of balanced or unbalanced impedances at frequencies between 100 kc/s and 20 Mc/s. Bridge and oscillator-detector separately available.

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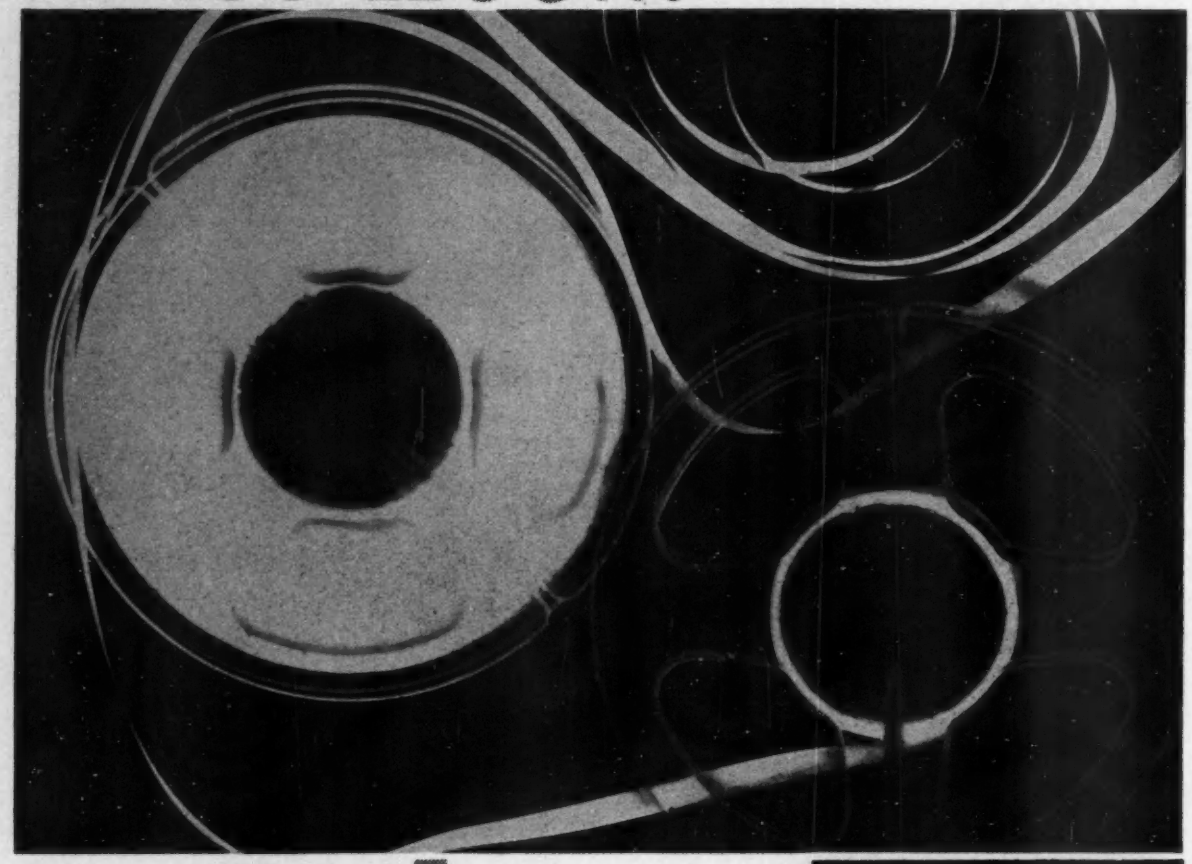

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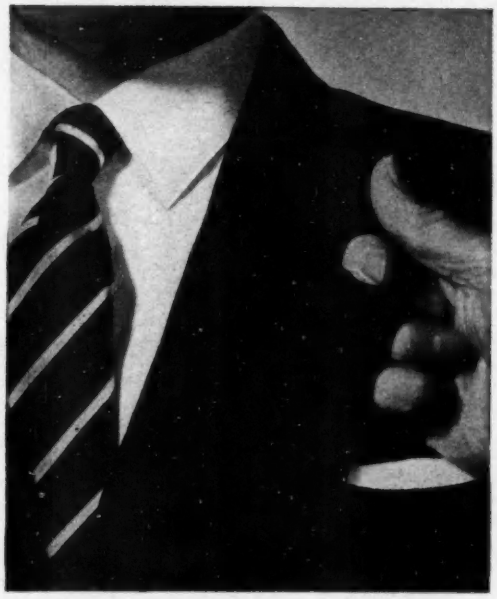

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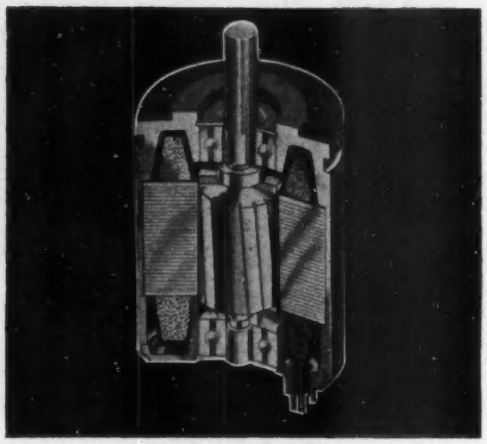

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ELECTRONIC ENGINEERING

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Commentary

IN the minds of most of the inhabitants of these islands 'Wembley' is principally associated with a certain Saturday afternoon towards the end of the winter season when, before a vast gathering of spectators and with all the paraphernalia of this modern age, twenty-two players get together for a brief hour and a half in a north western suburb of London to decide on the championship of the year.

Yet within a stone's throw of the arena where this annual event takes place is a set of buildings which has a much greater claim to fame.

The Buildings are of no great architectural merit but they house a research centre which has for some forty years established for itself a reputation which is unanimously acknowledged as one of the highest. It has contributed enormously to the advancement of knowledge particularly in the broad field of electrical science and while there are larger research institutions throughout the world housed in more modern buildings few are held in such esteem and affection as this particular research centre.

It is of course the other 'Wembley'—the Research Laboratories of the General Electric Company and now after this long period its structure and name are to change.

But this is no occasion for mourning for it is not the end of 'Wembley'. On the contrary it is a reshaping and remodelling—processes which in fact have been going on for the last twelve years or so—in order to keep pace with the requirements of modern research and development.

The pace of research in the post-war years has been phenomenal with new discoveries crowding in on us every day but what is frequently overlooked in this rush of new things is the way in which the pattern of research itself is changing.

It is a sign of the times that except in too few cases modern industrial research has no place for the individual 'researcher' Twentieth century research, in electronics as in other branches of science, is a team affair calling for a wide range of specialist knowledges and techniques and requiring well equipped laboratories, which is equivalent to saying that modern research is an expensive business which has got to be paid for, and unless a discovery is capable of commercial exploitation it can find no place in the research laboratory of an industrial organization.

But 'Wembley'—or to give it its new title, the Hirst Research Centre in memory of the Company's founder, the late Lord Hirst—is not to be a vast monolithic structure where the Organization Man predominates. It is largely to be decentralized and will consist of seven main operating groups each with a large measure of autonomy where, according to its Director, Mr. O. W. Humphreys, 'extensive programmes of fundamental research . . . . will be planned by our senior scientists in their knowledge of the Company's interests and forward thinking', and from these will derive 'the scientific discoveries, the inventions, the glimpses of the shape of things-to-come essential to the maintenance of technological leadership.'

Twentieth century research is not only expensive, it is apt to be long winded as well and a considerable period of time is necessary between the initial discovery and the final marketing of the product.

One need only quote the transistor as an example of what can happen when over enthusiasm outweighs caution.

As is well known, the point contact transistor was discovered in 1948 by Bardeen, Brattain and Shockley at the Bell Telephone Laboratories and it was heralded—and rightly so—as a scientific discovery of major importance bringing them the award of a Nobel Prize.

Yet it was over publicized and many of the claims made for it at the time just could not be substantiated. It proved unreliable, subject to all kinds of variations and exteremely difficult to manufacture in quantity. In short a much longer period of investigation was necessary before the transistor could be accepted as a satisfactory device.

What has now been evolved is the junction transistor which is a much more sophisticated and reliable affair than its predecessor of a mere twelve years ago. The theory of semiconductors on which the transistor action is based is now beginning to be understood and the way is being pointed to all sorts of fascinating and promising semiconductor developments such as the phenomenon of thermoelectric cooling in which the Wembley laboratories have played a leading part.

And so the pattern of industrial research is being formed. No longer is it the rather casual approach with scientists pursuing their individual fancies and preferences without regard to where the paths would lead. Instead it is now a planned operation with research running in parallel with engineering development and design at all stages, and it is on these lines that the new Hirst Research Centre will be based.

But there is to be no massive upheaval and apart from the new nameplate over the entrance, Wembley will continue much as it has done in the past with the Organization Man as its servant and not its master.

It is gratifying to learn that there will still be a place for the individual at the Hirst Research Centre and all who have had a soft spot for the old Wembley, will wish the Hirst Research Centre well.

COLD-CATHODE TUBE CIRCUITS FOR AUTOMATION

By R. S. Sidorowicz*, A.M.I.E.E.

(Part 1)

The following cold-cathode tube circuit elements are described; (1) four different pulse amplifiers; (2) four different delay circuits or univibrators; (3) three binary counters, three ring counters and a reversible or bidirectional ring counter; (4) three different logic OR *circuits and two logic* AND *circuits; (5) a shift matrix or register; (6) six different oscillators and multivibrators; (7) a drive circuit for a digital display tube. The circuits are based on resistors, capacitors and three types of cold-cathode triode (types: XC18, XC23 and XC24). A subminiature cold-cathode stabilizer tube, type XC12T, is used as a source of stable biasing or priming voltage. All the circuit elements are self-starting and automatically return to their rest position after completing their operating cycle. The elements form a consistent set of cold-cathode tube circuits which can be used in the designing of industrial automation systems. A method of combining the circuits in such a way as to build a fairly complex system is illustrated by three practical examples: an electronic dial, a programmed batch counter and an electronic inspection device. The systems built of the cold-cathode tube circuits employ mechanical contactors, switches and photo-resistors as input devices; the output facilities are usually provided by electromagnetic relays. The systems require a single stabilized power supply of 180V and can operate at speeds in excess of 100c/s.*

(Voir page 196 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 203)

THE automation of various production and testing processes in industry is regarded today as being not only highly desirable, but also perhaps inevitable. It is now widely accepted that the answer to automation problems lies in the field of electronics which can provide the necessary control elements. The reasons for the present 'vogue' for electronics are not hard to discover, if it is borne in mind that this science has progressed tremendously during the recent years and that today it is capable of providing control systems of great storage capacity, flexibility and complexity, and reliability and life compatible with those of mechanical systems. On the other hand, electronics can often provide a simple solution, where a comparatively complex electromechanical system has been used. Furthermore, the automation of some processes has only become possible because of electronics. These characteristics make electronics invaluable in small, as well as large-scale, automation systems and bring the fully automatic factories into the realm of practical possibilities.

Electronics today offers a large variety of devices and basic circuits, which cover a very wide range of speeds and power requirements. When confronting a specific automation problem it is often found that the solution meeting all the technical requirements can be provided by several alternative electronic systems. Under these conditions, the choice of a particular system will be based on economic considerations, maintenance and servicing facilities and such 'imponderables' as personal preferences, aesthetic considerations and the willingness and ability of a manufacturer to advise and help his customer.

One means of solving the problems of industrial automation is provided by circuits based on cold-cathode gas-filled tubes. Such circuits are primarily suitable for those control processes, where the speeds involved are of the order of the normal industrial frequencies. Before venturing any further into this field, it may be pointed out that no attempt will be made to discuss the economic aspects of cold-cathode tube systems or to compare them with other electronic devices. It should be mentioned, however, that circuits using cold-cathode tubes have the valuable property of being self-indicating. This feature can greatly simplify the problem of fault-finding and maintenance of the equipment.

* *Hivac Ltd.*

General Characteristics of Cold-Cathode Tube Systems

Cold-cathode tubes and the associated circuits have become fairly generally known during the last ten years. A substantial number of articles has been published, in which various aspects of cold-cathode tube systems have been discussed. The circuits described range from very simple basic elements to such complex systems as electronic directors or exchanges[1-22]. The known cold-cathode tube circuits can be divided into two basic groups depending on the technique of firing the tubes:

(1) Bias-plus-pulse circuits[1,2,3,4,5,6,7].

(2) Voltage-transfer circuits[17].

Recently, some novel cold-cathode circuits have been developed, where the advantages of the bias-plus-pulse and voltage-transfer techniques have to some extent been combined; these circuits are suitable for application in static control systems[19].

The bias-plus-pulse approach is characterized by the following features. A biasing voltage lower than the maintaining potential is first applied to the control electrode of the tube; the biasing voltage may have a comparatively slow rise-time (of the order of a few milliseconds). After a suitable time interval a comparatively short sharp pulse is applied to the electrode through a capacitor. The combination of the bias and the pulse is sufficient to fire the tube. A bias-plus-pulse circuit is usually based on cold-cathode diodes and triodes, resistors, capacitors and rectifiers. The circuit cannot normally be operated without auxiliary devices such as pulse generators, especially if cold-cathode diodes are used as the circuit elements[7]. The final result of this technique is therefore a hybrid system employing cold-cathode tube circuits and special waveform generators based on hard valves and rectifiers.

The voltage-transfer circuits[17] are based on what may be termed the bias-plus-bias technique. The control electrode is first biased to a suitable level which is insufficient to

effect its breakdown. A further voltage is then superimposed on the bias by means of a system of rectifiers. The two voltages are sufficient to trigger the tube and the tube will remain conducting as long as both the voltages are present. The voltage-transfer technique was devised to overcome some of the difficulties experienced in the triggering of certain cold-cathode tubes. However, the final result of this approach is a fairly complex circuit employing large quantities of metal rectifiers.

The recently described ACCESS[19] (Austin Cold-Cathode Electronic Switching System) employs numerous metal rectifiers in its logic circuits and its applicability is somewhat limited by the fact that, basically, it is a static switching system.

It appears therefore that in the field of cold-cathode tube circuits there is some scope for new developments and improvements. In particular, it should be worthwhile to simplify the circuits by eliminating the rectifiers and avoiding the auxiliary electronic equipment (e.g. pulse generators). In this way it would be possible to design a consistent cold-cathode tube system based on resistors, capacitors and cold-cathode tubes. The only auxiliary equipment would be a stabilized power supply.

In the following a set of cold-cathode tube circuit elements, which avoid rectifiers and auxiliary electronic equipment, is described. The simplified circuits have been made possible by employing several types of cold-cathode tubes in such a way that larger tubes are used to control smaller tubes. Some of the circuits are entirely novel, while others are basically modified versions of some known circuits. For the sake of completeness some well-known standard circuits are also included. Apart from meeting the requirements listed above, the circuits have a useful property of being self-starting. This means that upon switching on the supply voltage, a given circuit element will automatically assume its 'zero' or rest position.

The circuit elements are based on the bias-plus-pulse technique, since only this type of circuit offers the possibility of avoiding rectifiers. The circuits are also characterized by the fact that after completing their operating cycle they automatically return to their rest position.

The Components Employed

The following types of cold-cathode tube are used in the circuits: XC12T, XC18, XC23, and XC24. The principal characteristics of the first three tubes are indicated in Table 1. The diode, type XC12T, is a stabilizer tube and is used in the circuits as an auxiliary device. It is based on a pure-metal cathode and, since it is provided with a certain amount of tritium which produces the priming electrons, it can be operated in total darkness. The remaining tubes use a barium-oxide coated cathode and, in order to ensure reliable operation, they should be provided with adequate illumination (not less than 2 foot-candles). On the other hand these tubes should not be used in direct sunlight, since this may appreciably affect their transfer characteristics.

The subminiature tube, type XC18, is a triode having a continuous operating current of 1mA. The type XC23 is a miniature triode whose maximum continuous current is 7·5mA. Both the tubes are furnished with flying leads and transparent envelopes. The glow in the tubes is clearly visible from the end opposite to the flying leads. Though the continuous current ratings of the tubes are 1mA and 7·5mA, respectively, these values can be exceeded two- or five-fold, provided the tubes are operated at a suitable mark-to-space ratio. The tube, type XC24, is a subminiature double-trigger triode. Its characteristics are basically similar to those of an XC18, except that the tube can be ignited by either of the two triggers, the remaining trigger being earthed through a suitable resistance.

The significance of the static parameters indicated in Table 1 is fairly clear. As regards the dynamic parameters V_p and t_x (which are of importance in switching applications) and their measurement, the reader can find detailed information in some recently published articles[2,7,15,20,24]. Those interested in the physics of electrical discharge in gases may be referred to a number of textbooks and recent publications[25,26,27,28,29].

A further item may be added to the above complement of cold-cathode tubes. This is a digital indicator tube, referred to as a 'Numicator', type XN1. The device is not a switching tube and its sole function is to provide a clear digital read-out of the final result. Such tubes are today becoming increasingly popular and are very much appreciated by the unskilled operators who work with modern electronic equipment. The Numicator has the following characteristics: breakdown voltage (anode to any one cathode) 180V max., maximum mean anode current 2·0mA, maintaining voltage (at 1·5mA) 130V (nominal), extinction voltage 125V and maximum anode current 3·0mA.

The resistors employed in the circuits usually have the power rating of $\frac{1}{2}$W (or less), though some resistors with 1·0W rating are required, especially with the miniature XC23. The resistor tolerances are normally ±5 per cent, but the resistors which are used for bias transfer (e.g. between the cathode of a tube and the trigger of the next tube) or for limiting the trigger current can have ±20 per cent tolerances. The circuits employ some high-value resistors (above 1·0MΩ). Certain types of these resistors have a tendency to change their value, even if they are operated at very low currents. It is therefore necessary to ensure that only high-quality stable resistors are

TABLE 1
The principal characteristics of the Hivac XC18, XC23 and XC12

TUBE TYPES / PARAMETER	XC18 (SUB-MINIATURE)	XC23 (MINIATURE)	XC12 OR XC12T (SUB-MINIATURE)
Minimum main gap (anode-cathode), breakdown voltage, $V_{as(min)}$	210V	200V	104V (nominal)
Nominal main gap maintaining voltage, V_{am}	73V at 1mA (±5V spread)	67·5V (±5V spread)	85V
Nominal control gap (trigger-cathode) breakdown voltage, V_{ts}	68V (±6V spread)	70V (±6V spread)	
Nominal control gap maintaining voltage, V_{tm}	55V	55V	—
Maximum continuous cathode current, I_k (max)	1mA	7·5mA	1mA
Maximum transfer current (d.c.), I_t	30μA	90μA	
Recovery time, t_x	1msec max.	1·8msec max.	
Dynamic transfer sensitivity, V_p	85V max.	88V max.	
Dimensions	34×10·5mm	45×19·1mm	28×6·75mm

employed in the range above 1·0MΩ. The capacitors are usually of the metallized-paper type and have tolerances of ±20 per cent. However, the trigger pulsing capacitors can be ceramic and their tolerances can be slightly wider. It is advisable for the capacitors to have the normal voltage rating of 250V (or more), since otherwise their leakage may prove troublesome, particularly when they are used in combination with comparatively high resistances.

The circuits require a stabilized +180V power supply. A stabilized power pack for +180V and 60mA can be designed comparatively easily and simply by employing a single series valve, a single amplifying valve and a cold-cathode diode (type XC12T) as the reference-voltage source. The power pack should not be connected directly to the circuits. It should first be switched on and warmed up; this normally takes only a few minutes. Next, the circuits are connected to the supply by means of a separate switch. In this way it is possible to ensure that the circuits will be set at their 'zero' positions. The above does not apply to the digital indicator tube, type XN1, which requires a special supply.

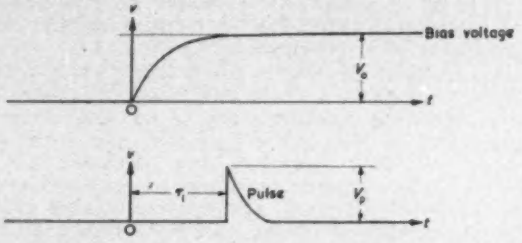

Fig. 1. Relationship between bias voltage and pulse

The Circuit Elements

It has been mentioned that the bias-plus-pulse circuits are characterized by the fact that the bias to a particular trigger electrode has to be applied before the pulse. The bias voltage usually has a comparatively slow rise-time (of the order of a few milliseconds). Consequently, the pulse should be delayed until the bias is fully 'established'. The situation is illustrated in Fig. 1. Even if the biasing source has a fast rise-time, the voltage which appears at the trigger will be 'slowed down' by the presence of a pulsing capacitor. The pulses applied to the triggers through a capacitor have a sharp leading edge (of the order of a few microseconds). The pulses may have an exponential tail (see Fig. 1) and are transmitted to the triggers with very little distortion. Alternatively, the exponential pulses at the triggers are obtained as a result of the differentiation of a fast voltage step.

When the circuit elements are combined into a control or automation unit, it is necessary to provide such a system with suitable input and output facilities. Such devices should be comparatively simple and be compatible with the circuits in that they should use the same power supply. The inputs to the cold-cathode tube circuits can easily be derived from mechanical contactors, microswitches, limit or proximity switches, vacuum photocells or cadmium sulphide photo-resistors. These devices are required to deliver negligible power in order to actuate a circuit, but the voltage amplitudes should not be less than 50V. The method of connecting the input devices to the circuits is explained below.

The cold-cathode tubes employed in the circuits are not powerful enough to drive directly any mechanical equipment. However, the larger tube, type XC23, has a sufficient current capacity to operate a heavy-duty relay which is capable of switching on or off suitable electrical equipment.

The circuits described are divided into the following groups: pulse amplifiers, delay circuits or univibrators, counters, logic circuits, matrix or shift register elements, and oscillators and waveform generators. In general, the values of resistors and capacitors are indicated in the diagrams. These values are such as to ensure that a given circuit will operate satisfactorily. However, they are not necessarily the optimum values which would result in the best operating conditions and the longest possible life for the circuits.

Only a general description of the functioning of the circuits is given and no attempt is made to describe their behaviour analytically.

Pulse Amplifiers

These circuit elements are 'amplifiers' in the sense that a comparatively weak input signal is transformed into a stronger signal which is suitable for driving a number of cold-cathode tubes. On the other hand, the shape of the output pulse bears no resemblance to that of the input signal. Further, no linear relationship exists between the amplitudes of the input and output signals.

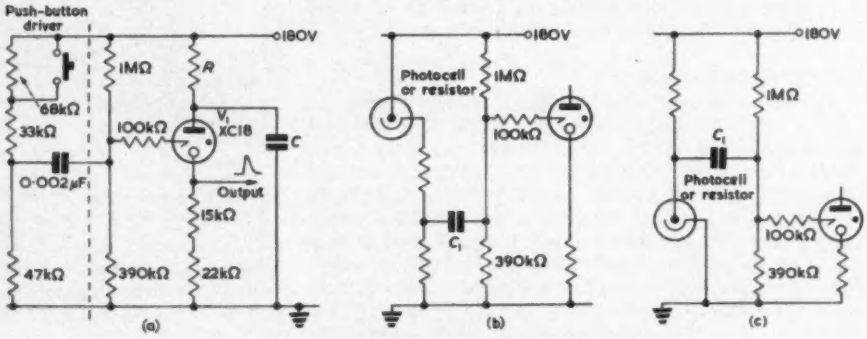

Fig. 2. (a) Push-button-operated pulse amplifier (pulser)
(b) Triggering of a cold-cathode tube by means of a photocell which is normally off
(c) Triggering of a cold-cathode tube by means of a photocell which is normally on

The simplest amplifier or pulser is shown in Fig. 2(a). The tube operates under the self-quenching conditions, i.e. after being triggered by an input signal it discharges the anode capacitance C and becomes extinguished. If the tube is an XC18, the minimum values of the circuit components are: $R_{min} = 3{\cdot}3M\Omega$ and $C_{min} = 0{\cdot}01\mu F$. This gives the cathode time-constant of $\tau_k = 0{\cdot}37msec$. With the triode, type XC23, the anode resistance can be lowered to 1·8MΩ. For the same τ_k it is therefore possible to increase

C and reduce the cathode resistance. This will result in a lower output resistance of the pulser. Under certain conditions it may be possible to make C as low as 0·005μF. Due to the comparatively large values of R and C, the operating speed of the pulser is about 10 to 15c/s, the amplitude of the output pulse at the cathode being 100V. The circuit can easily be gated by an external bias source. For this purpose the 1MΩ is removed and the lower terminal of the 390kΩ is returned to the biasing source.

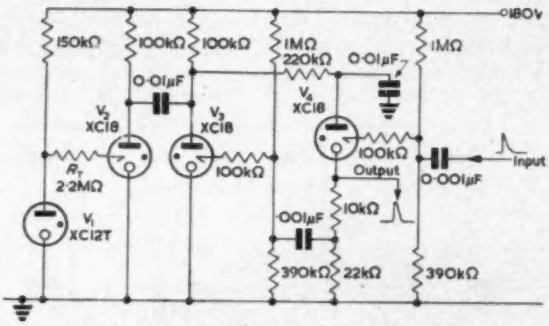

Fig. 3. Pulse amplifier based on a monostable binary circuit

Fig. 2(a) shows a push-button operated circuit for pulsing the amplifier. It should be clear that the push-button can be replaced by a microswitch, a limit or proximity switch or by any mechanical contacts. With this type of drive the operating speeds may be lower than 10c/s. It is then advisable to increase C in order to ensure that the tube will not be spuriously fired by contact bounce. Figs. 2(b) and 2(c) illustrate how the amplifier can be operated by a vacuum photocell or a photo-resistor. The circuit of Fig. 2(b) triggers the tube when the photo-element becomes illuminated. In the circuit of Fig. 2(c), the photocell is normally illuminated and the voltage drop across it is comparatively low; when the light is removed, a pulse is produced and this fires the tube. In both cases it is required that the voltage change be at least 50V. The coupling capacitor C_2 can be as low as 0·002μF, but in the case of a cadmium-sulphide photoresistor this will have to be increased, since its rise-time is comparatively long (of the order of 10msec or more).

Another type of amplifier is shown in Fig. 3. The device consists of a monostable circuit (tubes V_1, V_2 and V_3) and a pulsing tube V_4, whose anode charging network (220kΩ and 0·01μF) is connected to the anode of V_3. The trigger of V_2 is permanently biased from V_1 through R_T, so that V_2 becomes ignited as soon as the circuit is switched on. V_2 is normally non-conducting, so that the anode capacitor of V_4 charges to the full supply voltage. When V_4 is triggered by an external signal, its anode capacitor is discharged (down to about 70V) and a fast-rise, exponentially decaying pulse is produced across the cathode resistance. The pulse has an amplitude of about 100V. A fraction of the pulse is used to trigger V_3. When V_2 becomes ignited, V_3 becomes extinguished due to the presence of the coupling capacitor[2,15]. However, as soon as the anode potential of V_3 reaches a suitable value (lower than V_b = 180V), V_3 becomes re-ignited and V_2 is extinguished. The anode potential of V_3 then rises to +180V and consequently the capacitor of the pulsing tube is recharged. The circuit can operate at frequencies up to 100c/s and it can easily be controlled by an external bias source. The biasing resistance R_T should be between 1·0MΩ and 2·2MΩ. If it is required to increase the output pulse power, V_2 and V_3 can be replaced by a pair of XC23's. The anode resistances should then be reduced (e.g. 22kΩ instead of 100kΩ) and the capacitances increased (0·05μF instead of 0·01μF); similar modifications can be introduced into the anode circuit of V_4, while its cathode resistance can be reduced.

Fig. 4 shows a rectangular-pulse generator which can be used as an amplifier. This is a modified version of the circuit described earlier[15]. The device consists of a monostable circuit (V_1, V_2 and V_3), a pulsing tube (V_4) and a timing circuit (V_5 with RC). The triggers of V_2 and V_5 are permanently biased, so that V_2 becomes ignited as soon as the supply voltage is switched on, while V_5 is ready to strike when its anode voltage rises to a suitable value (about 120V). When an external firing pulse is applied to the trigger of V_4, a fast voltage step is produced across its cathode resistance (47kΩ). The duration of the pulse is controlled by the RC network of V_5 and the potential divider consisting of 390kΩ and 330kΩ. When its anode potential is raised sufficiently (from the cathode of V_4), V_5 fires and produces a pulse across its cathode resistance. The pulse fires V_2 and this results in the extinction of V_2 and V_4. The pulse at the cathode of V_4 is therefore

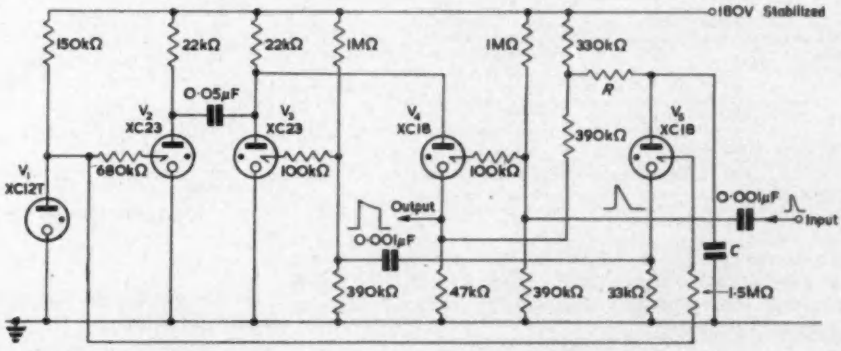

Fig. 4. Rectangular-pulse generator (pulse amplifier)

'terminated'. However, V_2 re-fires when its anode reaches a suitable potential and V_3 is extinguished thereby. The anode potential of V_3 then rises to +180V. With R = 330kΩ and C = 0·005μF (these are the minimum values), the duration of the output pulse is about 3msec and the generator can operate at frequencies up to 50c/s. The amplitude of the output pulse is about 70V. The monostable circuit of the generator can be based on the subminiatures, type XC18, but in this case it is necessary to reduce its capacitance and increase its resistances. The generator can easily be controlled by an external bias which should be applied to the trigger of V_4.

Another pulse amplifier is shown in Fig. 5. The circuit is an inverted resistance-coupled bistable pair. When the supply voltage is switched on, V_2 becomes conducting;

this is due to the fact that, because of the *RC* network (0·005μF and 470kΩ) in the trigger circuit of V_1, the initial bias voltage of V_2 is higher than that of V_1. When V_2 strikes the pulse developed across the cathode resistance may be as high as 100V. However, the final voltage at the cathode is about 40V. The trigger-cathode voltage of V_1 is therefore about 50V. When an external pulse is applied to the circuit, V_1 becomes ignited. This results in a sudden rise of the common cathode potential which extinguishes V_2. The next pulse will re-ignite V_2 and extinguish V_1. The pulses obtained across the common cathode resistance have an amplitude of about 65V. The circuit can be operated at frequencies up to 500c/s. Two

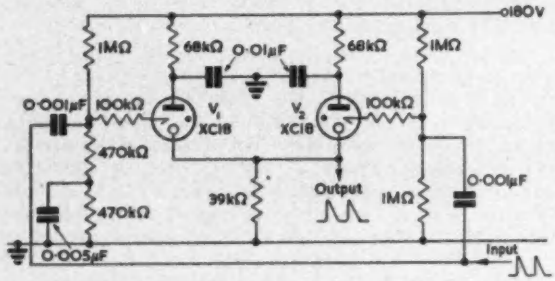

Fig. 5. Pulse amplifier based on a cathode-coupled binary circuit

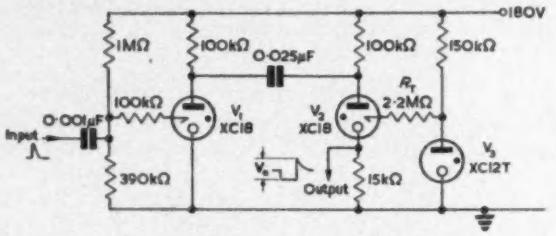

Fig. 6. Simple two-tube delay circuit (univibrator)

miniature tubes, type XC23, can be used in the circuit in order to obtain higher pulse powers, provided the anode and cathode resistances are suitably reduced and the capacitors increased.

Delay Circuits or Univibrators

In the bias-plus-pulse technique it is necessary to provide a delay between the application of a biasing voltage and the pulse voltage (see Fig. 1). Very often such delays can be provided by using suitable cold-cathode circuits. The shape of the pulses produced by these circuits is not particularly important, provided they generate a fast positive-going edge. The input pulse should have a well defined sharp leading edge in order to avoid jutter between the input signal and the positive output edge. The cold-cathode tube delay elements indicated below are monostable circuits (univibrators) which are capable of providing delays from about 3msec to several tens of seconds. They can cover the speed range up to about 250c/s.

Fig. 6 shows a simple univibrator consisting of two triodes and a cold-cathode diode. Normally, V_2 is conducting since its trigger is permanently biased through R_T (R_T = 1·0 to 2·2MΩ) from the anode of V_3. When an external pulse ignites V_1, V_2 is temporarily extinguished. However, when the anode voltage of V_2 rises sufficiently, V_2 re-strikes and produces a positive edge across its cathode resistance (15kΩ). The magnitude of the delay between the front edge of the input pulse and the positive output edge is determined by R_T, the two anode resistances and the anode coupling capacitance (0·025μF). With the values of the components shown in the diagram, the delay is about 5msec and the univibrator can operate at frequencies up to 100c/s. The circuit is not very suitable for work with cold-cathode circuits, since its output pulse

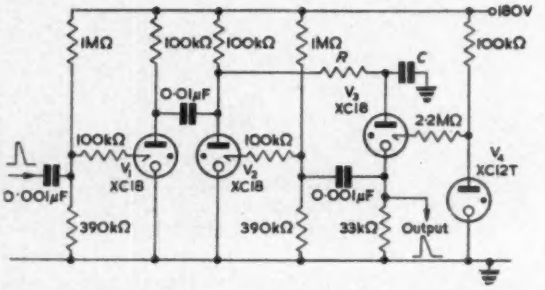

Fig. 7. Delay circuit (univibrator) based on an anode-coupled binary circuit

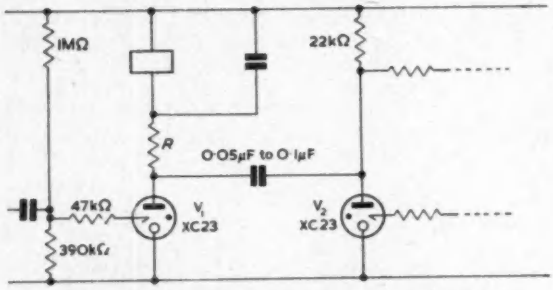

Fig. 8. Operation of a relay by means of a univibrator

has the peak amplitude of 25V. This is generally insufficient for triggering the cold-cathode tubes.

A different univibrator is shown in Fig. 7. A detailed description and analysis of this circuit was given in an earlier article[15]. The circuit consists of a capacitance-anode-coupled binary (V_1 and V_2) and a pulsing tube (V_3) whose trigger is permanently biased from the anode of V_4. Normally V_2 is conducting. When V_1 is fired by an external pulse V_2 becomes extinguished and its anode voltage rises to V_b = 180V. The capacitor *C* is therefore charged through *R* and, when its voltage reaches a suitable value, V_3 strikes and discharges *C* to the voltage $V_{am} \simeq 70$V. A delayed pulse having a fast rise and exponential tail is therefore produced at the cathode of V_3. This results in the re-ignition of V_2 and the extinction of V_1. The amplitude of the delayed pulse is 50 to 60V. With R = 220kΩ and C = 0·01μF (these are the minimum values) the circuit can work at frequencies up to 150c/s.

The univibrator of the type shown in Fig. 7 can be

used to operate a relay. For this purpose V_1 and V_2 are replaced by larger tubes (type XC23) and anode resistances and capacitance are suitably changed. The relay is connected in the anode circuit of V_1 and is by-passed by a capacitor in order to reduce the inductance surge when V_1 is extinguished. The modified circuit is shown in Fig. 8. The total resistance in the anode of V_1 should be above 15kΩ in order to limit the current to about 7·5mA. However, if the relay is operated comparatively infrequently, it is possible to reduce the resistance.

Another delay circuit is illustrated in Fig. 9. This consists of a resistance-cathode-coupled binary (V_1 and V_2) similar to the amplifier of Fig. 5, and a pulsing tube (V_3) whose trigger is permanently kept aglow from the anode of V_4. Normally, V_2 is conducting so that its

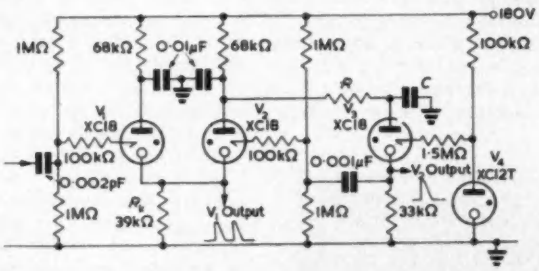

Fig. 9. Delay circuit based on a cathode-coupled binary circuit

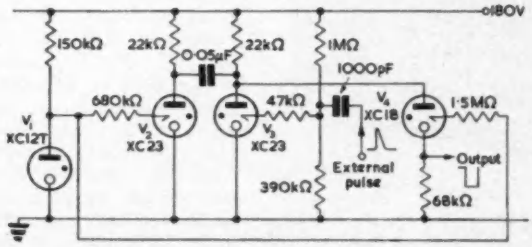

Fig. 10. Negative rectangular-pulse generator (univibrator)

cathode voltage is about 40V and the anode potential is about 110V. When a pulse is applied from an external source, V_1 is ignited and V_2 becomes extinguished. A fast-rising exponential pulse is therefore produced across the common cathode resistance (R_k = 39kΩ). The capacitance C is charged through R from the anode voltage of V_2, which rises to V_b = 180V. When the voltage across C reaches a suitable value, V_2 strikes and produces a fast-rising exponential pulse across its cathode resistance (33kΩ). The pulse re-ignites V_2 and results in the extinction of V_1. Another exponential pulse is therefore produced across R_k. It is seen that for each input pulse, the univibrator produces a delayed pulse at the cathode of V_2 (amplitude of about 50V) and two pulses at the cathodes of the binary (amplitudes of about 65V). The minimum values of components are: R_{min} = 1·0MΩ, C_{min} = 0·01μF. With these values of R and C the circuit can operate at frequencies up to 20c/s. This low speed limit is due to the fact that at higher frequencies the delay is strongly dependent on mark-to-space ratio.

Fig. 10 shows a univibrator which operates as a negative pulse generator. The circuit comprises a capacitance-anode coupled binary based on two XC23's (V_2 and V_3) and a pulsing tube (V_4). The triggers of V_2 and V_4 are permanently biased from V_1, so that both these tubes are normally conducting. The voltage developed across the cathode resistance of V_4 is about 70V. When V_3 is ignited by an external pulse, V_2 and V_4 become temporarily extinguished. However, when the anode voltage of V_2 reaches the value V_{as} (anode strike voltage when the tube is primed), V_2 re-strikes. Consequently, V_3 is extinguished and its anode potential begins to rise. When a suitable potential is reached, V_4 re-strikes and produces a fast-rising positive edge across its cathode resistance (68kΩ). The positive edge can be used as a delayed pulse. With the values of the components shown in Fig. 10, the amplitude of the positive edge is about 60V and the duration of the pulse is 2·5msec. The circuit can work at frequencies up to 200c/s. The duration of the pulse can be controlled by varying the anode coupling capacitance.

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(To be continued)

A High Speed Analogue to Digital Convertor

By N. Winterbottom*, B.Sc., and J. S. B. Walters†, B.Sc.

In many situations where large amounts of information are processed by electronic equipment the information exists in both analogue and digital forms in different parts of the system. In such cases a need arises to convert information from analogue to digital form.

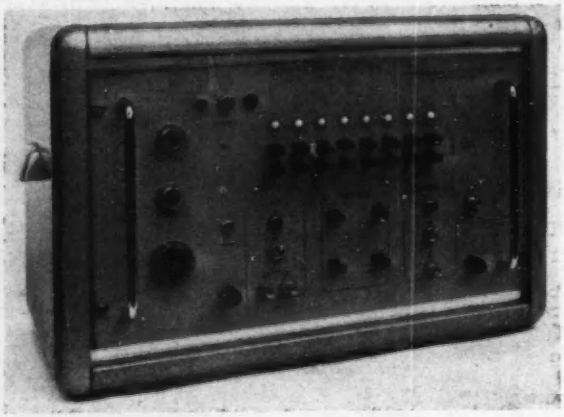
An account is given of a high speed analogue to digital convertor capable of performing 55 000 conversions per second from an analogue voltage to an 8-bit binary code. The equipment uses transistors as the active elements.

(Voir page 197 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 204)

THE increasing use of digital techniques for information processing has brought with it a need for various types of analogue to digital conversion equipment. The availability of such equipment would eliminate present bottlenecks where analogue information is manually converted into digital form for processing in digital equipment. A few examples will illustrate the problems and indicate some of the future possibilities.

A single test flight of an aircraft or missile may provide an amount of information in analogue form equivalent to several million binary digits in order to describe the behaviour of the machine. The inclusion of an analogue to digital convertor at some point in the recording and analysing chain makes this information available in a form suitable for analysis by digital computer.

In schemes for the automatic control of industrial processes now being planned it will be necessary to transmit information over lines or radio links and process the information digitally. In this case conversion of the signals to digital form before transmission allows accuracy to be maintained throughout a complex system.



The complete instrument

In the field of automatic computation the two major tools are the analogue computer and the digital computor. Some problems can be done more easily on one rather than the other. For example, the performance of a dynamic physical system which includes non-linear elements is usually determined by analogue simulation, whereas the digital computer is particularly suited to statistical analysis. Where an investigation involves both types of problem there is a requirement for the transfer of information between the two types of computer. High speed convertors are essential to handle the volume of information involved.

General Description

The convertor described in this article will carry out 55 000 conversions per second. The input signal is an analogue voltage lying between 0 and + 6V. The output is an 8-bit binary signal available in both serial and parallel forms.

The block diagram is shown in Fig. 1. The sequence of operations during a conversion cycle is as follows.

The control, using a 'set 00' pulse, first sets up the number 01111111 (most significant digit first) on eight transistor bistable circuits which comprise the store. In decimal notation, this number is 127 which is approximately the mid point of the full range from 0 to 255 provided by eight binary digits. The store outputs are connected to eight electronic switches, S_1 to S_8, which provide accurately determined outputs of zero or −6V, depending on whether the corresponding digits in the store are zeros or ones. The −6V is derived from a stable reference voltage supply. The switch outputs feed a series of precision resistors in the analogue adder. Resistor values are chosen to give currents into the summing point proportional to the arithmetic weightings of the digits in the code. Thus, with the simple binary code used here, the resistor values increase by factors of two from the most significant to the least significant digit. The total current from the adder is compared with a current derived from the analogue input voltage, the output of the comparator indicating which of the two signals is the larger. A 'set 1' pulse generated by the control circuit using the comparator output sets the first store element to a '1' if the current from the analogue input is greater than that from the adder. Otherwise the first digit is left as a '0'. At this stage in the cycle the control also sets the second store element to a '0' ready for the next comparison. The signal performing this function is designated 'set 0'.

In this way the eight digits are set up in a sequence. When the last digit has been set a transfer pulse is generated to indicate to external equipment that the conversion cycle is complete and that a parallel output may be taken from the store. A serial output is available from the control circuit during the conversion process.

With the convertor operating at its maximum speed a comparison for a digit takes 2μsec. This fixes the digit period of the serial output at 2μsec. One extra digit period occurs between conversions which allows a well defined time during which the parallel output can be used. The total conversion time is thus 9 × 2 = 18μsec.

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Control Circuits

Logic Circuit Elements

The circuit of the control loop is built up from a number of basic elements designed around the surface barrier transistor type SB345, which allows the use of direct-coupled circuits. Detailed descriptions of the basic properties of these transistors can be found elsewhere[1-4]. The essential elements used in the present convertor are the invertor, the bistable circuit, parallel and series AND and OR gates and the binary counter. Fig. 2 depicts their configurations and Fig. 3 the logic symbols used. The use of the binary circuit in Fig. 2(e) necessitates using more coupling components than the d.c. coupled binary, but is less expensive on transistors.

Digit Drive

The digit drive or clock pulses may be derived either

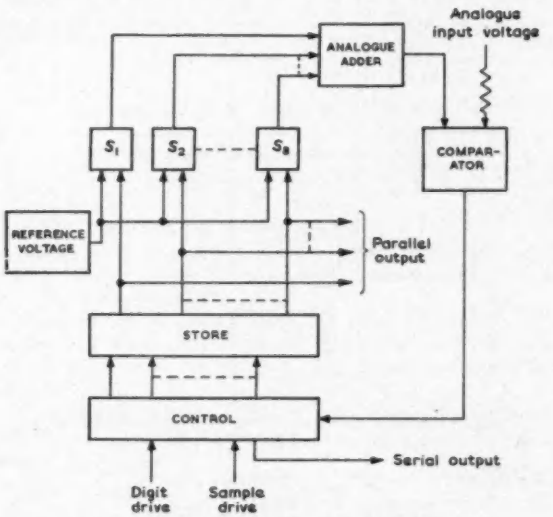


Fig. 1. The arrangement of the analogue-digital convertor

from an internal crystal oscillator or from an external source. The pulses are shaped and fed to a series of four delay circuits in cascade. The outputs from the delay circuits consist of four pulse trains, which at the maximum digit repetition rate are 0·5μsec pulses every 2μsec. Fig. 4 shows the circuit and Fig. 5 the waveforms produced. It will be realized that the pulse width from the delay circuit is a preset time of 0·5μsec irrespective of the clock frequency. The pulse trains produced in this way are used for timing the gate operations during the conversion cycle.

Sampling

As with the digit drive, sample instructions can be fed from external sources or internally locked to the maximum compatible with digit frequency, i.e. 1/9 of the digit frequency. Manual control is provided by a press-switch, which enables the use of the convertor as a single-shot device whose reading appears on signal lamps.

Fig. 6 shows the essential elements of the logic feedback loop which is driven from the 'sample' and which controls the setting operations of the store. The idealized waveforms are drawn in Fig. 7 using the convention that the positive level represents the left-hand state of a bistable and the negative level the right-hand state or NOT condition.

The 'sample' drive input sets the bistable S to the S condition, which in conjunction with timing pulse 4, $\overline{R}$ and D_8 sets the bistable P. The presence of $\overline{R}$ and D_8 indicates that all the controlling elements are in the correct condition for a sample to be initiated. The gate which combines P and the timing pulse from the first delay produces the 'set 00' pulse, used for setting the mid-scale position (01111111) of the store. The third timing pulse of the same digit period and P sets R.

The R bistable is the main controlling bistable circuit of the logic loop. It controls the gates which drive the 8-way switch, the 'set 0' pulses, the 'set 1' pulses and

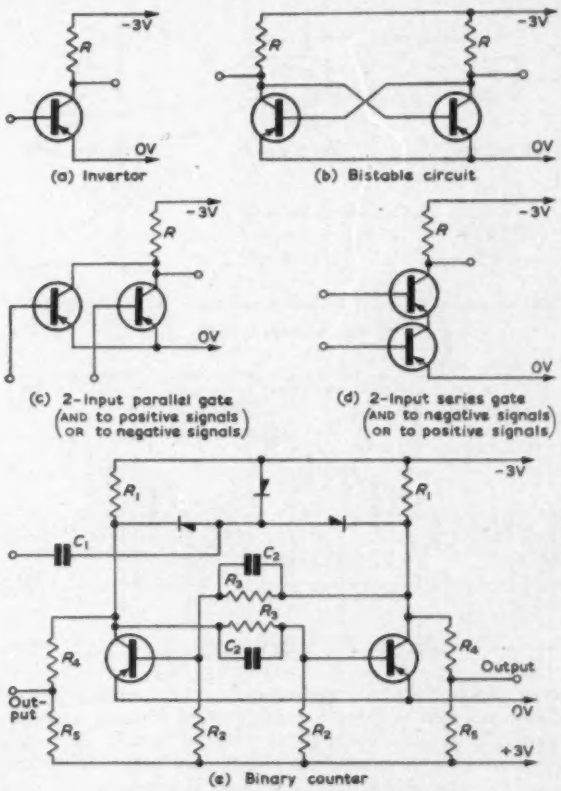


Fig. 2. Basic circuit elements used

the resetting of the P and S bistables. The latter two operations ensure that only one 'set 00' pulse per sample is produced, and that further external 'sample' pulses are rejected until the end of the conversion cycle.

As can be seen from Fig. 7, the R state is maintained for 8 digit periods before resetting occurs on timing pulse 2 and D_8 (the last switch position). During this time the R AND 1 are gated together to provide the 8 'set 0' pulses for the store, while R AND 4 are gated together with output pulses from the comparator to set the T bistable.

This latter bistable (T in Fig. 8) acts as a temporary store for the comparator decisions, allowing the 'set T' (serial output) to be accurately timed by the first timing delay pulse of the next digit period.

The R output is also combined in an AND gate with the third timing delay to drive the 8-way switch. The resulting 8 pulses per sample drive three cascaded binary circuits whose outputs are combined in 3-input AND gates to produce a set of 8 pulses (the D-waveforms) which are one digit period long, and succeed each other in time

as in Fig. 7. Fig. 9 shows the combination of the connexions which achieve the desired result.

During the time that both the P and R bistables are in their NOT conditions a gate produces a 'transfer' pulse as in Fig. 7. It thus occurs immediately after the last 'set 1' pulse and indicates that the store is ready for a parallel transfer of digits to ancillary equipment.

The 'set 00', 'set 0', 'set 1', (serial output) and 'transfer' pulses are coupled via d.c. buffer amplifiers to output sockets for use in external equipment.

The foregoing description contains the theoretical gating arrangements and bistables required to operate the

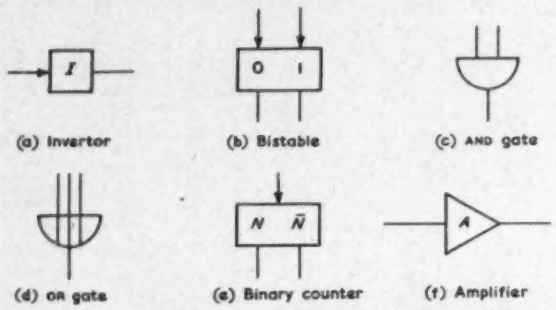


Fig. 3. Logic symbols

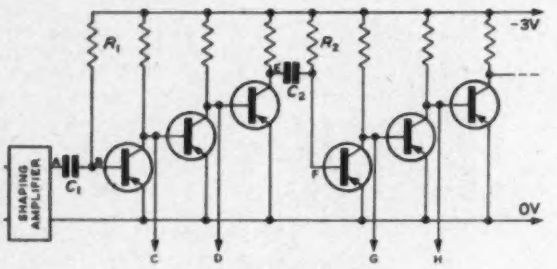


Fig. 4. Delay circuits

store during the conversion cycle. In practice, circuit delays necessitate using a slightly more complex arrangement. It is also essential to remove certain combinations of bistable conditions which may occur at switch-on. For instance $\bar{P}$, $\bar{R}$ and $\bar{D}_8$ is a condition which does not arise in normal sampling, and one which if it occurred at switch-on would remain even if 'sample' instructions were given. An invertor in the D_8 output and an additional OR gate for setting the R bistable removes this condition.

Store and Drive Gates

Logic Elements

Fig. 10 shows the logic circuit of a store element, together with the 'set' lines which drive it. The initial comparison condition (01111111) is derived from the 'set 00' pulse through OR gates. This sets '1's' on all stores with the exception of the first element where the gate drives to the '0' side of the bistable. The AND gates which permit access of '1's' or '0's' are timed by the D-waveforms derived from the 8-way switch. Thus a 'set 1' pulse will set the n^{th} store only when D_n is present. A 'set 0' pulse, which is coincident in time with the 'set 1' pulse, is routed by D_n to the $(n + 1)^{th}$ store. Since the comparator gives rise to one digit per digit period, and the D-waveforms succeed each other during the same interval, it can be seen that the sequence of events which sets '1's' and '0's' progresses along the store.

Practical Store Circuit

In practice the 'set 00' pulse is gated to the right-hand side of each store element (except the first which goes to

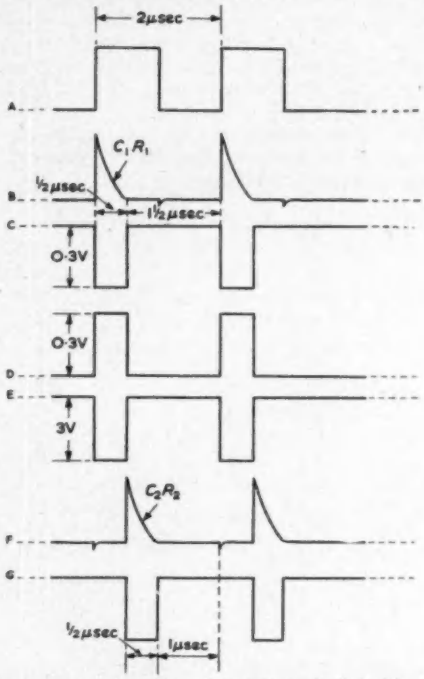


Fig. 5. Idealized waveforms derived from circuit in Fig. 4

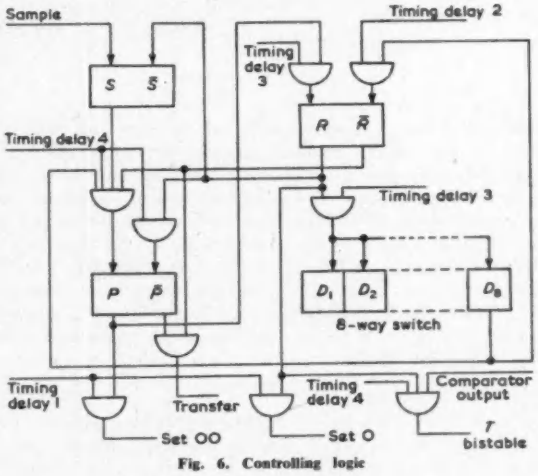


Fig. 6. Controlling logic

the left-hand side) via the collector load. This removes the requirement for a set of gating transistors but necessitates using a specal amplifier capable of supplying collector current to all elements during the 'not set 00' time. This arrangement is shown in Fig. 11. The 'set 0' and 'set 1' pulse trains are gated to the store via the emitters of the driving transistors. In this way the bases of the same transistors can be used for gating the appropriate D-waveforms, making one transistor into a two-input AND gate.

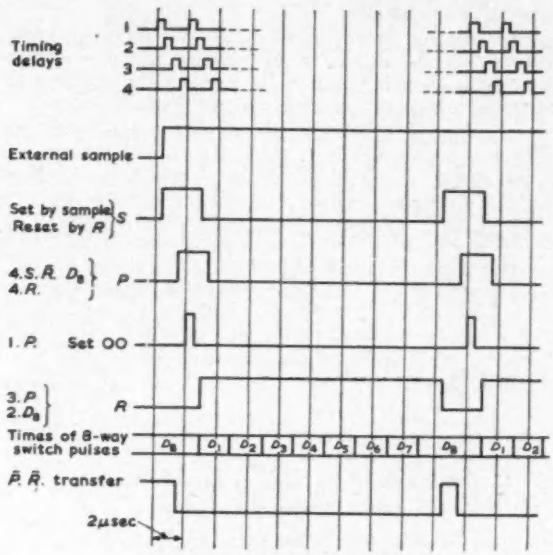


Fig. 7. Idealized controlling waveforms
(Vertical lines at 2μsec intervals)

Precision Switches and Analogue Adder

Each switch connects a resistor chain of the analogue adder to the −6V reference supply when driven by a '1' from the store (Fig. 12).

The first chain gives rise to the most significant digit current of 2mA across the 6V. The resistance of each chain increases by a factor of two for each succeeding resistor chain.

The resistor chains are made up of metal film resistors, selected to give an accuracy to each chain of 0·01 per cent.

The switches contain three surface barrier transistors as in Fig. 12. The emitter-follower (VT_2) coupled with the action of C ensures that VT_3 is driven hard either way.

The switching transistor VT_3 is used with its emitter and collector terminals reversed. Although the current gain is reduced, the rise and fall times between the two states are shorter. In this way the required accuracy of switching is obtained within the time available.

The collector load of VT_3 and that of all equivalent transistors in the other seven switches is 1kΩ, and these give rise to a typical V_{ce} of 40mV in the saturated condition. To maintain the required accuracy, this 'error voltage' is cancelled at the summing point which rests at −40mV. Transistors are selected to ensure that their V_{ce} values lie within given limits.

Reference Voltage Supply

The reference voltage supply provides the stable voltage to the eight electronic switches. The maximum current drain is 48mA. Since the current waveform contains frequency components from d.c. up to several megacycles per second, the output impedance must be kept low over the whole frequency range.

The method of stabilization used is shown in Fig. 14.

In the circuit of Fig. 15 the Zener diode MR_1 is the primary reference element (R). This provides a nominal voltage of 5·1V at an impedance of about 6Ω when passing a current of 20mA. Although the temperature coefficient of the diode is less than 1mV/°C it is not stable enough for the present application without further precautions. The local ambient temperature is therefore stabilized as described below.

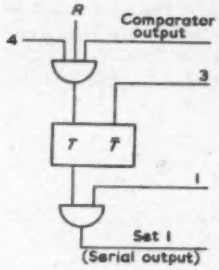
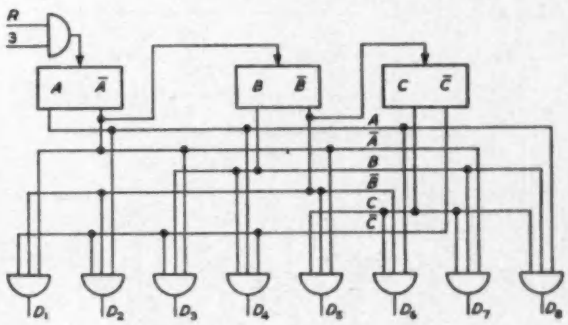


Fig. 8. Set 1 (serial output) gating

Fig. 9. (below) 8-way switch



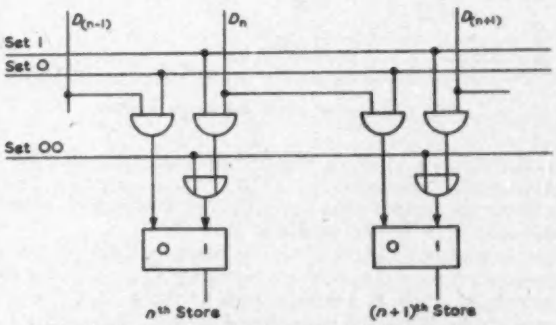
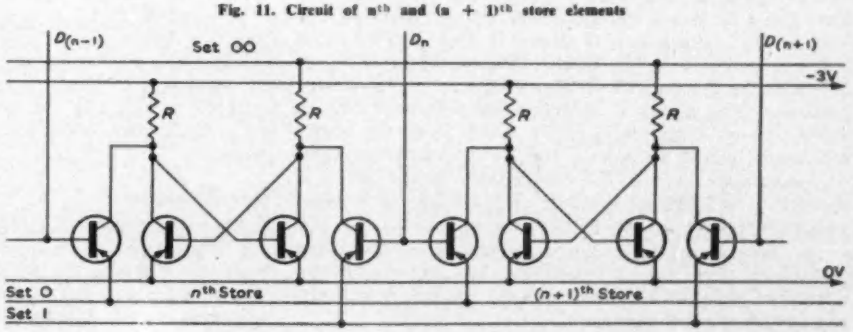


Fig. 10. Logic circuit of n^{th} and $(n + 1)^{th}$ store elements

Fig. 11. Circuit of n^{th} and $(n + 1)^{th}$ store elements



The amplifier input stage consists of a long-tailed pair, VT_1 and VT_2. This configuration was chosen to minimize the effects of changes in base to emitter voltage with temperature. The magnitude of this effect is about 2mV/°C. The drifts in VT_1 and VT_2 would ideally cancel out, but but variations from transistor to transistor may have an out of balance of as much as 0·4mV/°C. To reduce drift due to I_{co} effects silicon transistors are used in the input stage. The current to the long-tailed pair is supplied from a separate stabilized line. It can be shown[5] that connecting the Zener diode MR_2 to point A instead of point B results in a marked reduction of output impedance.

The loop is completed by the compound emitter-follower consisting of VT_3, VT_4, and VT_5, the last one acting as the series element S.

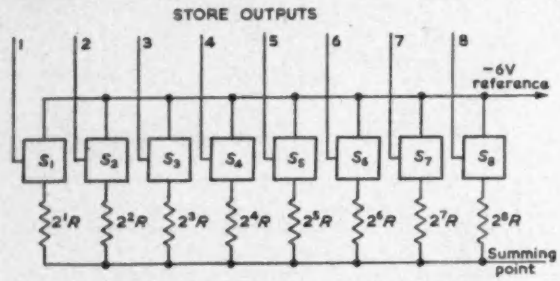


Fig. 12. Precision switches and analogue adder

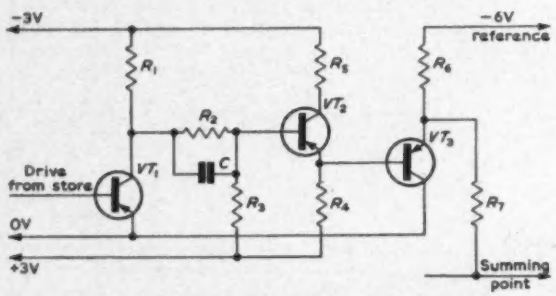


Fig. 13. Circuit of switch and driving amplifier

Capacitors C_1 and C_2 improve the high frequency performance of the circuit. The output capacitor, C_3, reduces the output impedance at high frequencies where the loop gain of the stabilizer falls off.

It is evident from the preceding paragraphs that thermostatic control of the ambient temperature is necessary to reduce the drift of critical circuit elements. The reference diode, MR_1, and transistors VT_1, VT_2, VT_3, and VT_4 are therefore mounted in a copper block, the temperature of which is stabilized by a transistor feedback loop. The design is based on an article by H. Kemhadjian[6]. The circuit configuration is shown in Fig. 16. VT_6 and VT_7 are mounted in the block. The variation of I_{co} in VT_6 provides a signal which senses changes in block temperature. The signal is amplified by VT_7 and VT_8 to drive a power output stage, VT_9, which feeds the heater coil wound round the block. By this means the variation of temperature around the components in the block is reduced by a factor of about 30 over a range of ambient temperature from 0°C to 40°C.

The complete circuit provides a reference supply which is stable to better than 0·1 per cent when subjected to the maximum expected variations of load current, input voltage and ambient temperature.

Comparator Amplifier

The common summing point of the anologue adder resistors and the resistor in the external analogue voltage line are connected to the input base of the comparator amplifier and their currents summed algebraically.

The amplifier, which changes its state according to the difference in current, is a differential amplifier feeding a single ended output stage. High frequency micro-alloy diffused transistors (2N501) are used (Fig. 17).

Temperature stability is maintained by inserting the transistors in a copper block oven whose temperature is controlled by the same sensing arrangement as that of the reference power supply oven.

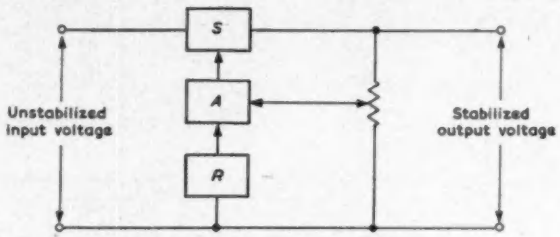


Fig. 14. Reference voltage supply

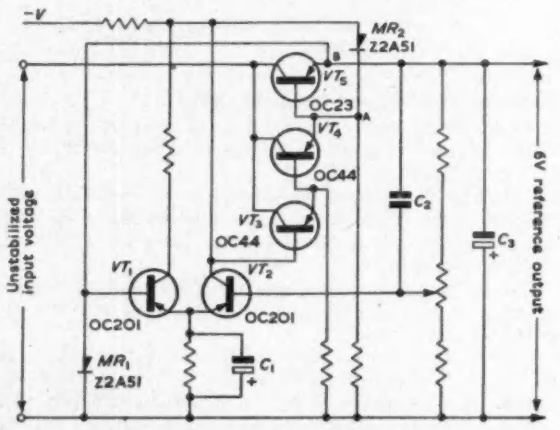


Fig. 15. Reference voltage supply circuit

The working point of the input base is set to −40mV by means of the 'set V_{co}' potentiometer. The 'set datum' potentiometer allows a small d.c. offset current to be injected into the summing point to set the convertor output to zero with the analogue input earthed.

Output Circuits

In addition to the 'set 1' serial output, the store outputs are fed through d.c. buffer amplifiers to provide a parallel output. These appear as either sets of negative or positive 3V pulses from 3kΩ impedances. For the purpose of checking the instrument or reading the result of a single conversion visually, lamp indicators are also included.

Power Supplies

The logic circuits, store, switch drive and output circuits are driven from ± 3V transistor stabilized power supplies built into the unit and driven from a mains transformer. The switches and comparator derive their power from the reference power supply previously described. A low

current +6V reference line supplies the positive voltage to the long-tailed pair of the comparator. An unstabilized −6V line supplies power for the indicator lamps.

Overall Specification

Digit Rate:—Any frequency to max. 500kc/s (inc. press-button).

Sample Rate:—Any frequency to max. of 1/9 digit rate (inc. press-button), i.e. 55 000 samples/sec maximum.

Analogue input:—Minimum full scale input 0 to 6V. Input impedance 1·5kΩ for 0 to 6V full scale input.

Digit Outputs:—8-bit simple binary code. Serial or parallel (positive or negative) 3V pulses d.c. connected from 3kΩ.

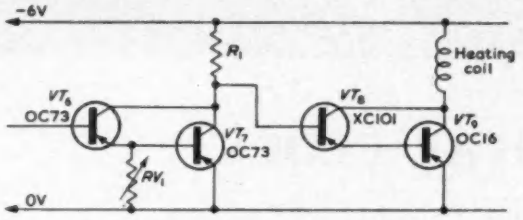


Fig. 16. Temperature stabilizing circuit

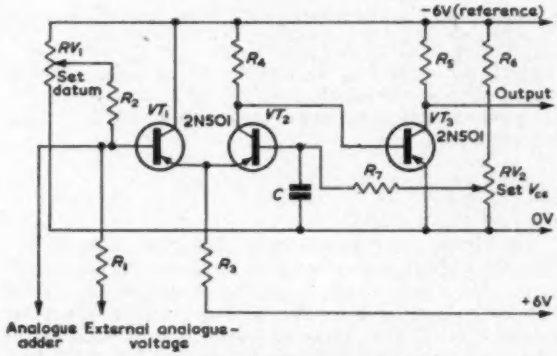


Fig. 17. Comparator amplifier

Synchronizing Outputs: set 00, set 0, transfer, 3V pulses, all d.c. connected from 3kΩ.

Temperature Range:—0°C to 40°C.

Accuracy:—$\pm\frac{1}{2}$ least significant digit ±0·25 per cent.

Power Supply:—200/250V, 50/60c/s, 11 W.

Construction

All units, including power supplies are constructed on plug in boards. The mating sockets are fixed to a chassis which is fixed to a standard 19in rack-mounting panel.

Low Noise Electro-Mechanical Sampling Switch

In most applications of digital data handling methods where a number of variables are to be recorded or otherwise processed, the analogue digital convertor is interposed as early as possible in the chain and shared between the various information channels on a time division basis.

Consequently some form of channel selection device becomes an essential component of an analogue digital convertor when more than one source of information is to be handled. Such a device must introduce the minimum of inaccuracy, i.e. it must have the lowest possible inherent noise, while crosstalk should not be developed between the channel being sampled and the remainder.

The A.W.A. low noise sampling switch was developed to meet these requirements and is considered to have something 'in hand' for most applications. In practice the noise level is found to be less than 5μV peak-to-peak when running at 100rev/sec, while the contact resistance is less than 10mΩ.

The switch utilizes a motor driven cam which operates pairs of contacts sequentially to give the equivalent of a rotating selector arm running over a commutator-like set of channel segments. The diagram (Fig. 18) shows a typical single contact pair assembly with the associated operating cam. The cam lift is transmitted via push-rod (b) to the inner of the pair of beryllium copper contact springs, each of which carries a domed silver contact. The entire contact assembly can easily be adjusted in the plane

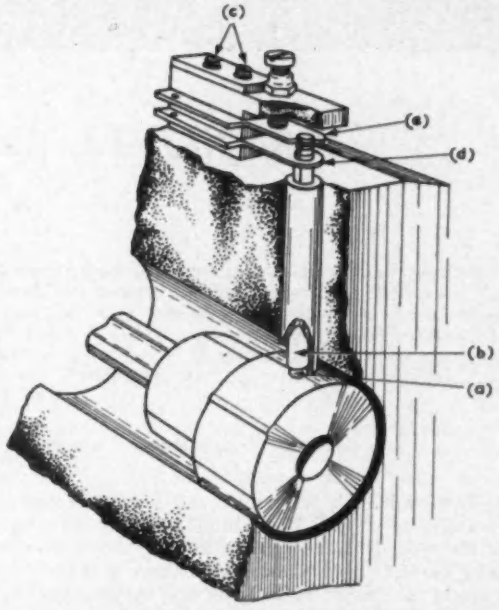


Fig. 18. Cross-section of typical single contact pair assembly

of the axis of the push-rod by two screws (c) to obtain varying amounts of return pressure on the push-rod from the element (d). The outer contact (e) can be adjusted to obtain the correct gap, and to compensate for movement of the inner contact resulting from adjustment of return pressure.

Channel contact pairs are generally arranged in multiples of twelve; two groups of twelve being inter-digitated in a common block to give a basic twenty-four channel bank. It will be appreciated that many variants can be obtained by altering the number of banks of contacts and the profile of the cams.

Acknowledgments

Acknowledgment is due to the Directors of Sir W. G. Armstrong-Whitworth Aircraft Ltd, for permission to publish this article.

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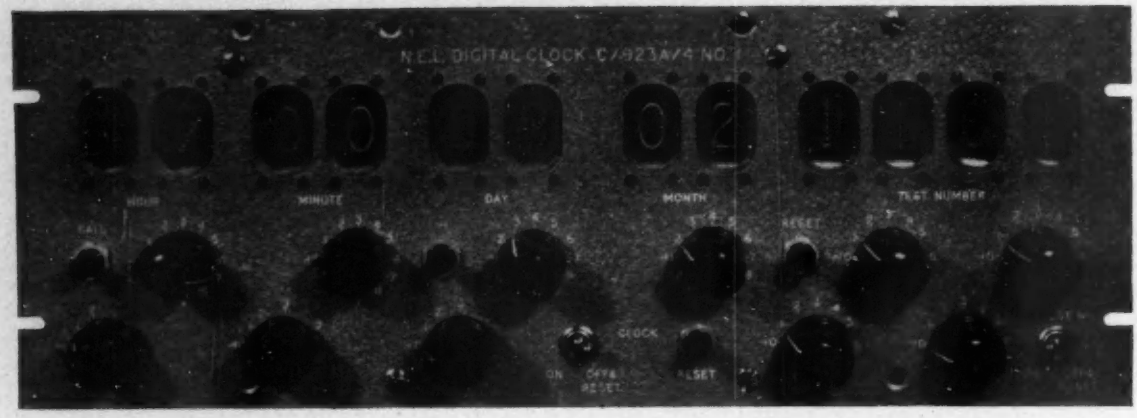

A NOVEL DIGITAL CLOCK

By A. Russell*

The design and operation of a novel digital clock which registers the month, day, hour, minute, experiment number and test number on illuminated in-line indicators is described. All this information, plus the year, is available in serial read-out form and may be punched on paper tape and/or typed on a solenoid-operated electric typewriter. The resetting method used permits the rapid setting up of new configurations. The existing laboratory frequency standard supplies the accurately spaced pulses which drive the calendar section, this therefore serves as a monitor of the long term accuracy of this frequency standard.

(Voir page 197 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 204)

THE digital clock described has been designed and constructed at the National Engineering Laboratory, East Kilbride. It is installed as part of the instrumentation of the test rig for hydraulic turbines in the hydraulic machinery laboratory and forms one information source of a digital data-logging system.

Minutes, hours, month, experiment number and test number are registered on in-line edge-lit type indicators. The calendar section is driven by pulses from a frequency standard[1] and the first two digits of the test number shown on the panel in Fig. 2 and above are preset and used for experiment number. The remaining two digits represent the test number which has unity added to it each time a read out is made. Either section can be set to any desired reading at any time. All the data exhibited, with the addition of the year, is available as a consecutively scanned decimal output which may be used in conjunction with a solenoid operated electric typewriter, a paper-tape punch, or other recording device. The output may be programmed to permit the insertion, where desired, of such functions as 'space' or 'TAB', and the order and number of items recorded may be varied. The apparatus is operated from 24V d.c.

Circuit Arrangement

A block schematic of the several divider stages required is given in Fig. 1. The natural 'count of twelve' of the miniature uniselector used lends itself well to the ÷3, ÷4, ÷6 and ÷12 stages but the ÷10 stages necessitate a 'jump' of two counts per cycle.

The 'days' and 'hours' stages operate as follows. The 'hours' stages receive 'hand on' pulses from the minute stage. The 'hours, units' uniselector divides by 10 for two cycles and by 4 for the third cycle, passing a pulse to the 'hours, tens' stage on completion of each count. The 'hours, tens' uniselector, counting 0-1-2; 0-1-2; etc. divides by 3 and passes a pulse to the 'days' stage on completion of the count. A total of 24 input pulses will thus produce 1 output pulse. The 'days, units' uniselector divides by 10 for 3 cycles and by 1 for the fourth cycle and passes a pulse to the 'days-tens' stage on completion of each count. The 'days-tens' uniselector, counting 0-1-2-3; 0-1-2-3; etc.; divides by 4 and passes a pulse to the 'months' stage on completion of its count. Months of less than 31 days are 'made-up' to 31 by use of the '+1' button at the end of the month.

The 'read-out' control has an interlock from the first divider stage; this ensures that a 'read-out' will not be made while any of the uniselectors in the divider stages are in motion.

Component Details

Uniselectors

The new telephone-type miniature uniselector[4] was chosen for the divider stages as it was felt that the much reduced size and the plug-in facility more than compensated for the reduced number of arcs. Several combinations of 'make-before-break' and 'break-before-make' arcs are available and it was decided that a uniselector with one m.b.b. arc and two b.b.m. arcs would be most useful. This was adopted as the standard and used throughout the digital equipment in the scheme.

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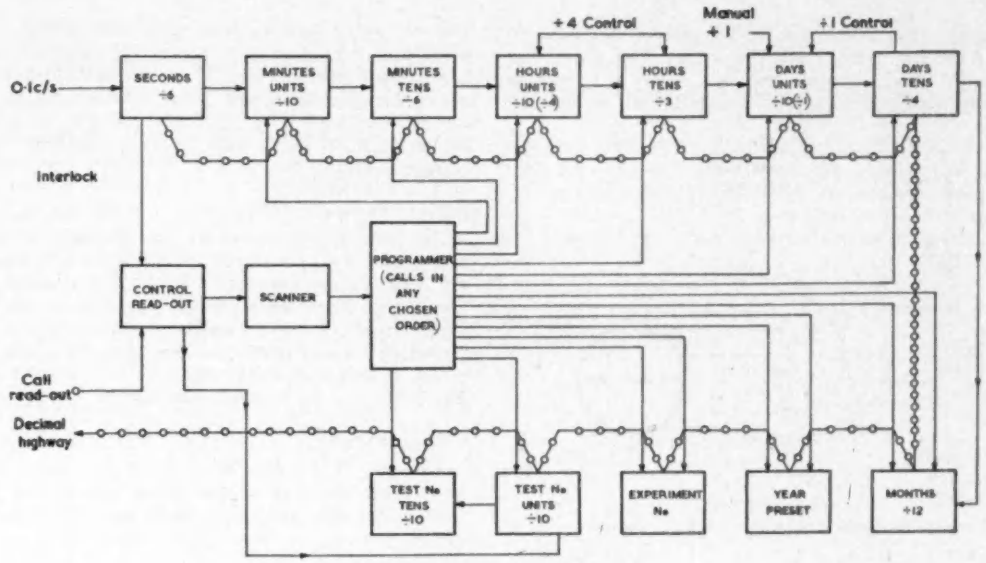


Fig. 1. Block schematic of digital clock

Relays

Remanent relays[3] were found to be more convenient than the conventional relays when used as information stores in conjunction with the uniselectors. These allow the normal 'latching' circuits to be dispensed with.

Visual Indicators

It was decided that the visual indicators should be of the 'edge-lit' type, since these would operate satisfactorily from the 24V supply serving the uniselectors. The projection type of indicator has the advantage of a wider viewing angle but occupies more space and is less brightly illuminated than the edge-lit type.

Chassis

In the prototype, the chassis (Fig. 2) was made of angle brass and served as a means of assembling the four standard Post Office type relay mounts, each capable of holding ten relays. The front panel is shown on page 150; the 'in-line' indicators are mounted behind windows in this panel and have their escutcheon plates removed so that the necessary set of indicators could be accommodated in a standard 19in panel.

Divider Operation (Hours Divider)

Count and Reset to Zero

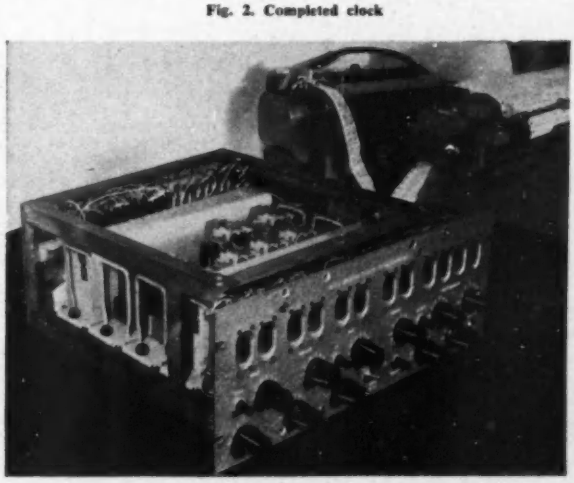
The actions of the various divider stages are very similar and vary only in the number of steps used to complete the operation. The hours divider stage is a typical example and is shown in Fig. 5(a). The hours-units divider uniselector is designated *USHU* and the hours-tens divider uniselector is designated *USHT*. The associated hand-set switches are designated *HSHU* and *HSHT*. *RHU* and *RHT* are the respective resetting remanent relays while *HRR* is used to change the first stage from ÷10 action to ÷4 action.

The output pulses from the minutes-divider stage are applied to the coil of *USH* at terminal *HDI* (hours-divider input). At the end of each pulse the wiper arms of *USHU* will 'step' to the next position and cause the appropriate numeral to be illuminated in the visual indicator of the stage. Also the 'highway' arc $USHU_3$ will cause the *CHU* (call-hours units) line to be switched to the appropriate line of the highway. (The highway leads to the typewriter and punch and is common to all information sources.) Arc $USHU_2$ will cause a pulse to be handed on to *USHT* at position 9 and, with *HSHU* in the normal position (position 0), relay *RHU* will be switched on at position 10 (via pin 17). RHU_1 will cause line *z* to be earthed and this in turn causes two relays (in the control stage) to generate a 'buzz' signal which will appear at terminal *BR*. RHU_2 will pass this signal to *USHU* and the uniselector will 'step' until *RHU* is switched off on reaching position 12. The *BR* circuit will then be broken by RHU_2 and RHU_1 will switch off the 'buzz' generator if no other divider stage is calling for its operation. (The function of the 'buzz' generator is described below.) Uniselector *USHU* will now have counted ten input pulses, reset to zero again and have handed on one pulse to the next divider stage.

Alternative Homing Method

At this point some mention of the method for 'buzzing

Fig. 2. Completed clock



or 'homing' the uniselector at the end of a count, or during a manual reset, might be useful. The uniselector has its own 'buzz' contact and this causes it to step at some sixty steps per second. This facility can be used by

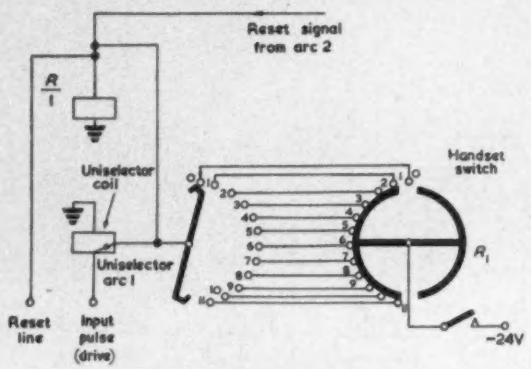


Fig. 3. Alternative method of "homing" uniselector

This relatively slow-stepping speed has proved useful in practice as the changing numerals may be observed during a reset sequence and can be an aid in fault-finding. The circuit for generating the 'buzz' pulses can be seen in the control stage (Fig. 4(b)) and consists of two relays *SR* and *CR* wired to form a relay 'flip-flop'. *SR* is a 'slugged' type.

Hours, Tens, Stage

The 'hand-on' pulse at the end of each 10 hours will pass (via TRA_5) to *USHT* which will move and switch the highway and indicator to the appropriate position. There is no need for a normal reset here as the ÷3 is a natural count for the uniselector, but provision is made for initial manual resets and the operation is the same as before except that *RHT* can only be switched 'on' via *RL(HT)* from the manual reset button.

Count of Four

Though ÷4 is a natural count, in this case it is used in only every third cycle. To avoid interference with the ÷10 cycles the uniselector is homed at the end of ÷4 cycles.

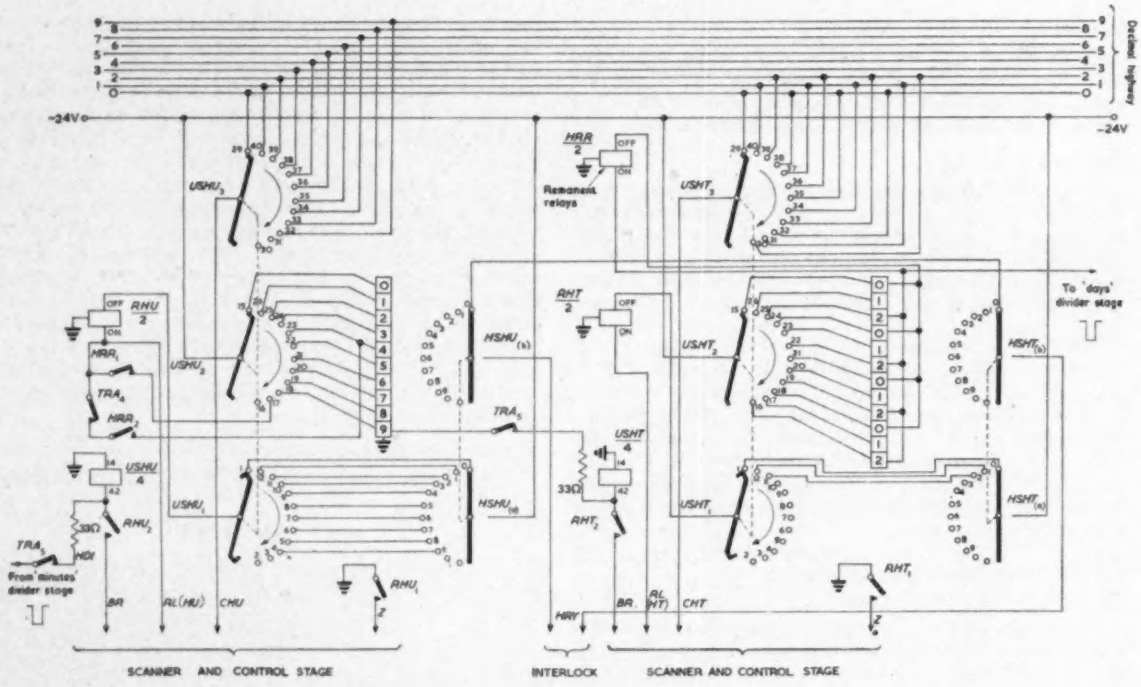


Fig. 4. (a) Hours divider stage

incorporating a 'short-all-but-one' type of switch at *HSHU*, feeding the wiper of uniselector arc to the *USHU* buzz terminal and using *RHU* to make and break the supplies to *HSHU* with a latch from uniselector wiper (Fig. 3). In practice it was found that the 'homing' run using this method was too rapid to ensure a positive 'hand-on' pulse for the next stage and the 'short-all-but-one' type of switch was not readily obtainable. As there was ample time available for the 'homing' run, a 10 pulses/sec buzz generator was included for this purpose.

It will be seen that a 'hand-on' pulse will be supplied by the hours-tens stage between indicator positions 2 and 0 and also that relay *HRR* is put 'on' during this time. When 'on', a count of twenty has taken place so that only a further count of four is desired. HRR_2 will now be closed and, when position four is reached by *USHU*, arc 2 will switch 'on' *RHU* and a reset to zero will take place. While 'homing' arc 2 will hand on a pulse from position 9 which will step *USHT* to position zero. This condition will register as zero hours (midnight) and the

stage is ready for a further count of 24. Contact TRA_4 prevents a 'sneak' circuit during manual reset.

Manual Reset

The extra wafer switch *HSHU(b)* is incorporated to ensure that the switch must be returned to zero after a manual reset for the interlock to be completed. The contact TRA_5 is one of the many 'transfer' contacts required in the apparatus. It will be seen that, under certain conditions, if stages were permitted to 'hand-on' pulses during a manual reset operation, it would be impossible to reset the clock to a specific configuration. The 'transfer' relays inhibit these 'hand-on' pulses during manual reset operations.

To reset the clock to appropriate date, time, and test number after a period of inactivity the following procedure must be carried out.

(1) Switch 'off' switch labelled 'clock on/off'. (This removes frequency standard pulses and energizes 'reset' button.)

(2) Switch 'off' switch labelled 'T.N. on/off'. (This energizes 'reset' button.)

(3) Set hand-set switches of various stages to required numbers. (The clock should be set 'fast' to allow for time taken to perform (5) below.)

(4) Press 'clock' and 'T.N.' reset switches in turn and ensure that stages reset to correct numbers as observed at visual indicators. (This causes reset relay *RES* in the control stage to energize the reset lines (*RL*) of all stages and thus initiate a reset run at each stage until the position decided by the hand-set switch is reached. The 'transfer' relay is also energized and *TRA* contacts open to inhibit 'hand-on' pulses.)

(5) Return all clock hand-set switches to their normal positions at '0' or '1' as denoted by the small arrows on the front panel. (This is not necessary for the 'tens' or 'months' stages, but it is good practice to treat all clock switches in the same manner.)

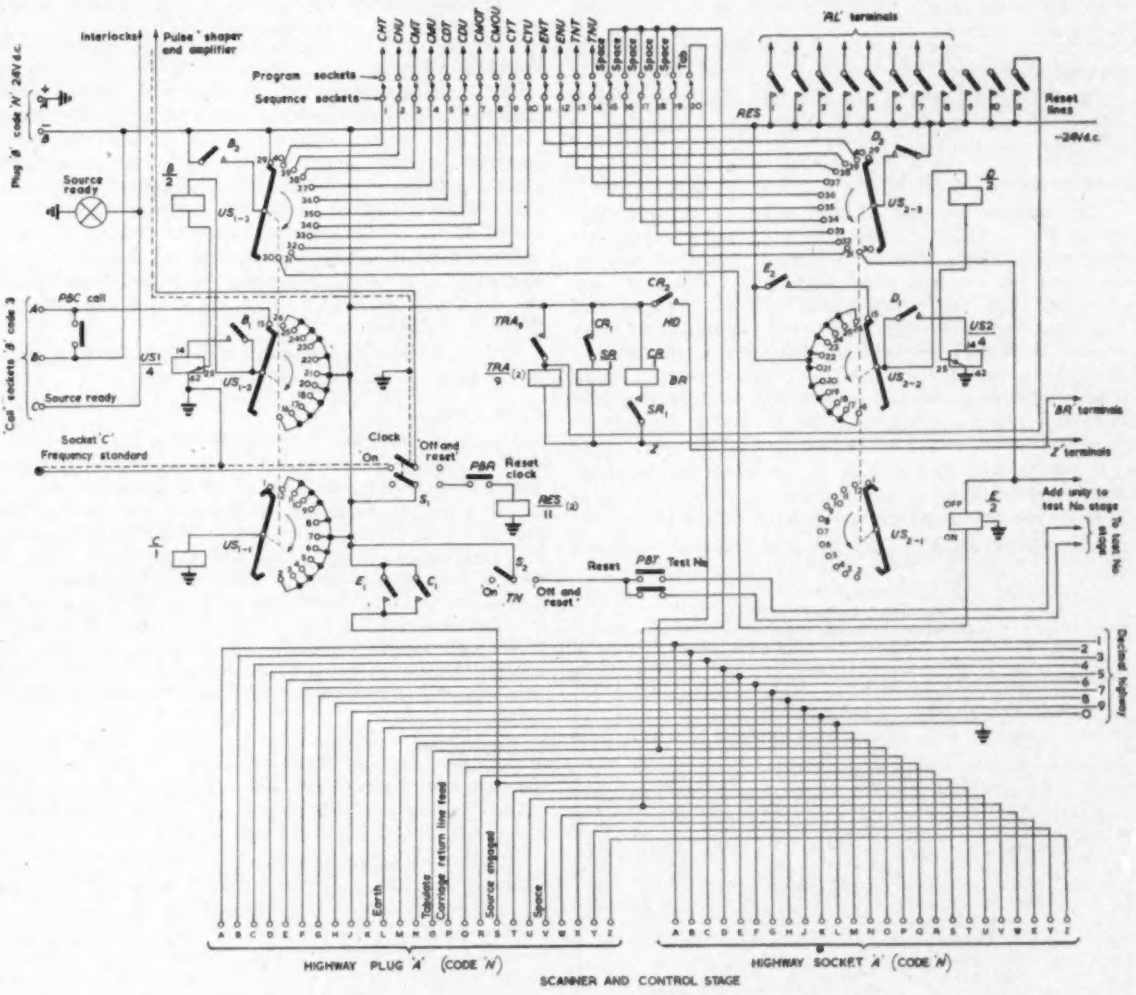


Fig. 4. (b) The control stage

(6) Return hand-set switches on test number stages to zero and switch 'on' T.N. switch. (Experiment number stages have no uniselectors and are 'statically' connected to highway via hand-set switches.)

(7) Switch 'on' clock switch at instant of synchronizm with time-check. (The seconds stage is reset to zero with the other stages and the clock can thus be set to within 10sec of accurate time.)

The clock will now register and give a read-out, when desired, of time, etc., to an accuracy determined by the frequency standard used. If left in continuous operation, the clock is an ideal long-term monitor of the frequency standard's accuracy.

Control Unit

The circuit diagram is given in Fig. 4(b) and a brief description will be given of the operation of sections not previously mentioned.

Scanner

The scanner consists of uniselectors *US1* and *US2*, relays *B*/2, *C*/1, *D*/2, and *E*/2 and "call" button *PB1* (Fig. 4(b)). When *PBC* is depressed relay *B*/2 will be energized via contacts $US_{1\text{-}2}$ and US_4. Contact B_1 will close and *US1* will be energized via $US_{1\text{-}2}$. Contact US_4 will open and de-energize *B*/2 which, in turn, will cause contact B_1 to open and thus de-energize *US1*. *When US1* is de-energized, the wiper arms will be moved to position 2 and the same action will be repeated, but this time *US1* and *B*/2 will be energized direct from the contacts of $US_{1\text{-}2}$ and not via *PB1* which can now be released.

It will be seen that contact B_2 will cause the sequence lines to be energized in turn, the sequence lines being programmed to call up the desired stages for the read-out.

The uniselector *US1* will continue stepping until the blank position (1) is reached; when position (12) is reached *E*/2 becomes energized and contact E_2 starts off the stepping action for uniselectors *US2* and in this way the number of "steps" is extended. Contact D_2 does the switching and, when position (12) is reached *E*/2 is switched "off" and a pulse is fed to the test number stage. The uniselector will come to rest at position 1. One complete scan will have been completed and all information recorded on typewriter and/or tape-punch.

Contacts C_1 and D_1 serve to originate a 'source engaged' signal for the duration of the complete scan.

The 'stepping' of the uniselector at typewriter speeds is described more fully elsewhere[2].

TABLE 1
Information highway coding

TERMINAL	CODE	BINARY VALUE						
		32	16	PARITY CHECK	8	4	2	1
A	One	0	0	0	0	0	0	*X*
B	Two	0	0	0	0	0	*X*	0
C	Three	0	0	*X*	0	0	*X*	*X*
D	Four	0	0	0	0	*X*	0	0
E	Five	0	0	*X*	0	*X*	0	*X*
F	Six	0	0	*X*	0	*X*	*X*	0
G	Seven	0	0	0	0	*X*	*X*	*X*
H	Eight	0	0	0	*X*	0	0	0
J	Nine	0	0	*X*	*X*	0	0	*X*
K	Zero	0	0	*X*	0	0	0	0
L	Common Earth (+ 24V)							
M	Typewriter Check N.C.							
N	Typewriter Check N.O.							
O	Tabulate ..	0	*X*	*X*	*X*	*X*	*X*	0
P	Carriage Return/ Line Feed ..	*X*	*X*	*X*	0	0	0	0
Q	Run Latch (−24V)							
R	Read Latch (−24V) ..							
S	Source Engaged (−24V)							
T	Plus (+) ..	0	*X*	0	0	0	0	0
U	Minus (−) ..	*X*	0	0	0	0	0	0
V	Space	0	0	*X*	*X*	*X*	*X*	*X*
W	Erase	*X*	*X*	*X*	*X*	*X*	*X*	*X*
X	Spare							
Y	Spare							
Z	Spare							

External 'Call'

The clock is treated in the same way as the other sources in the data-logging scheme and functions on a 3-wire 'call' system. Wire *C* is sensed by the master programmer to determine whether all the switches of the clock are in the normal position and also to ensure that the clock is not about to register a new position. This is sensed by an interlock in the "seconds' stage.

When these conditions are satisfied, the negative voltage appearing at *C* terminal permits the programmer to call the clock which it does by shorting *A* to *B* and initiating the scan as before.

A table of the information 'highway' coding is given in Table 1.

Reset Stage

The reset relay *RES* is energized when the reset button *PBR* is depressed with switch S_1 in the 'reset' position. This will cause the reset lines of all stages in the clock to be energized and all stages will begin to reset as described previously until the numbers set by the hand-set switches are achieved. Contact RES_{11} will cause relay *TRA* to receive the negative supply which will be latched over TRA_9; the positive supply will be supplied from *Z* when the first reset contact [e.g. RUH_1, RHT_1. . etc. (Fig. 4(a))] closes and remain until the last to open does so. This causes all hand-on pulses to be inhibited. It will be noted that relay *TRA* is operative only when a manual reset is called.

The manual reset of the test number stage is very similar but only two uniselectors are involved and these are operated from the two-pole switch *PBT*. The hand-on pulse between the unit and tens stages is inhibited by normally closed contact $RTNU_3$.

It will be noticed that both a 'highway' plug and 'highway' socket is provided; this is to permit a 'highway ring' between various sources of the data-logging scheme and removes the need of one 'highway' cable from each source to recorder. Copies of the complete circuit diagram may be obtained from the National Engineering Laboratory.

Acknowledgments

The work described has been carried out in the National Engineering Laboratory of the Department of Scientific and Industrial Research and this article is published by permission of the Director.

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A Versatile Forcing Function Generator

By J. Morrison*, B.Sc., A.Inst.P.

This article describes a forcing function generator designed for analogue computer use, which will provide sine, square, triangular, ramp, step or impulse functions to an accuracy of ¼ per cent full scale in frequency and amplitude. Frequency coverage is from 0·001c/s to 100c/s, and the device can be centrally controlled from the computer, or independently.

(Voir page 197 pour le résumé en français; Zusammenfassung in deutscher Sprache auf Seite 204)

INVESTIGATION of a physical system represented by a set of differential equations, on an analogue computer, often requires that the system response be determined when certain initial conditions are varied in a known manner.

The system may be an aircraft, whose pitching response to wind gusts is needed, or a car whose suspension damping requires optimizing to meet a variety of road conditions. Whatever the problem, some means of providing forcing functions or particular integrals (i.e. gust or road conditions) for a set of differential equations is essential.

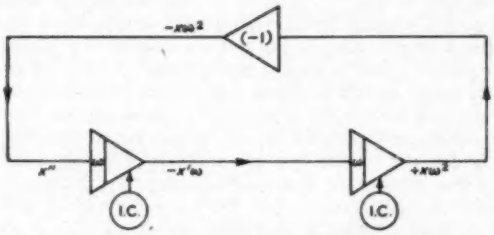


Fig. 1. S.H.M. set-up (i.c. = initial condition)

Specification

From the outset it was decided that the generator should be built into the existing LACE[1] installation at Warton, using d.c. computing techniques and that it should be controllable from the main computer or independently.

It should provide sine, ramp, step or impulse functions to an accuracy of ¼ per cent of full scale in amplitude (0·125V) and better than 1 per cent in frequency. The functions should have common amplitude, frequency and polarity controls and appear at a single output terminal on selection. In addition the unit should have stable characteristics, be easy to set up and to engineer, and should make use of existing LACE printed circuit amplifiers where possible.

To meet this specification, various computer set-ups were examined theoretically and of these an arrangement simulating simple harmonic motion looked promising. The equation $X'' + \omega^2 X = 0$ and Fig. 1 are well known to analogue computer users as a means of generating sine and cosine functions, and with refinements the computer set-up can also be made to generate ramps and impulse functions. However, the scheme was rejected on the grounds of inflexibility and a more sophisticated scheme was devised, based on an accurate ramp or triangular function.

Design Philosophy

To achieve built-in flexibility for the range of functions that could be generated, over and above those included in the specification, the design was centred around an accurate ramp or triangle generator. This could then provide the primary input to a biased diode module designed for the function required, namely sin X in the first instance. Thus, by changing diode circuit modules, a whole range of functions could be generated as and when required.

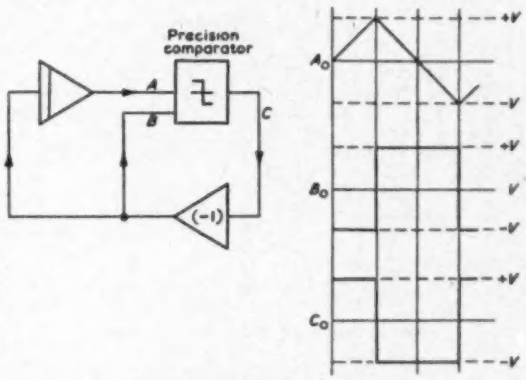


Fig. 2. Basic circuit and waveforms

Basic Principles

A block diagram showing the basic triangle circuit is shown in Fig. 2, and consists of two feedback loops.

(1) A precision comparator[2,4,5] whose output V_o is fed back on itself via a phase-inverting d.c. amplifier. This produces a bistable device which operates between precise limits $\pm V$ and has the transfer characteristics indicated in Fig. 3.

(2) An integrator whose input is V_B and whose output V_A feeds the comparator input.

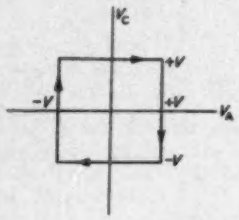
Addition of this integrator loop makes the bistable device free-running, giving a triangular waveform at point A, a square wave at point C, and waveform C inverted at point B (see Fig. 2). By short-circuiting the integrating capacitor, the device reverts to its bistable mode and may be pre-set to either level of $\pm V$; to give a triangle of positive or negative polarity when the short-circuit is removed.

To provide coarse frequency control the integrator time-constant may be switched to one of several values, fine control being achieved by varying the input to the integrator by means of a potentiometer. For single-shot work requiring a ramp function, a diode may be interposed between invertor output and integrator input, which will ensure a 'hold' condition on the integrator on comparator 'flip-over', whose duration will depend only on capacitor leakage, diode reverse resistance and

* *English Electric Aviation Ltd.*

grid current in the amplifier. Clearly, this arrangement will also provide impulse functions of opposite polarity at points *B* and *C*.

Step functions can easily be achieved by suitable relay switching of d.c. reference voltages, and amplitude control may be realized by using a potentiometer to vary the gain of an output d.c. amplifier in the usual manner.



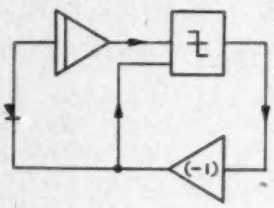


Fig. 3. (left) Transfer characteristic of bistable device
Fig. 4. (right) Basic ramp circuit

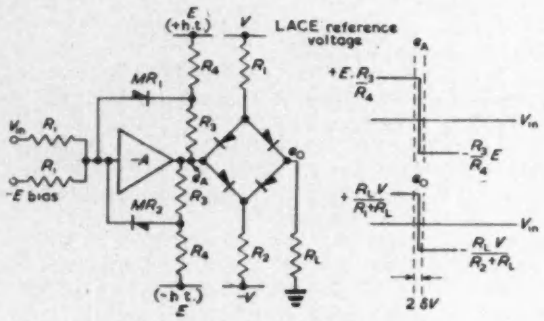


Fig. 5. Comparator circuit and waveforms

A useful feature of the device is the use of a frequency/period control which is common to all functions.

Basic Circuit Operation

Referring to Fig. 2, consider the integrator output at zero voltage (capacitor short-circuited) and the comparator output at $+V$ volts, giving $-V$ volts at the invertor output. When the short-circuit is removed the steady voltage $-V$ is integrated up, producing a positive ramp at the integrator output according to the equation:—

$$V_A = -1/pCR \cdot V_B$$

The output continues to rise until it reaches a level $(V + \delta V)$ when the algebraic sum of the comparator input voltages changes sign, causing an abrupt change in comparator output from $-V$ to $+V$ volts, lasting only microseconds if the comparator forward gain is high. This requirement is essential for accurate definition of limits $\pm V$, since the error voltage δv is given by:—

$$\delta v = V/A$$

where A is the forward gain.

On comparator 'flip-over' both its input B and the integrator input change sign together to $+V$ volts. The integrator then produces a negative going ramp from $+V$ to $-V$ volts, when at this level the comparator 'flips over' once more, giving finally a positive ramp running up to zero volts and beyond, thus completing the cycle.

However, if a diode is connected as shown in Fig. 4, then during the first transition waveform B will cut off the diode and open-circuit the integrator input, holding its output at $+V$ volts. This action produces a ramp function at point A.

Comparator

The most important part of the circuit is the comparator shown in Fig. 5. This is a precision device consisting of an output-limited high-gain d.c. amplifier, whose output voltage changes abruptly whenever the alegbraic sum of its input voltages changes sign. This drives a diode bridge limiter decisively into either limit to produce an accurately limited comparator characteristic. Diodes MR_1, MR_2 and resistors R_3, R_4 define drive voltages for the bridge and ensure that the amplifier does not become non-linear leading to undesirable 'hang-over' effects. In general the load resistor R_L, will be the input resistor of a following amplifier terminated at its summing point.

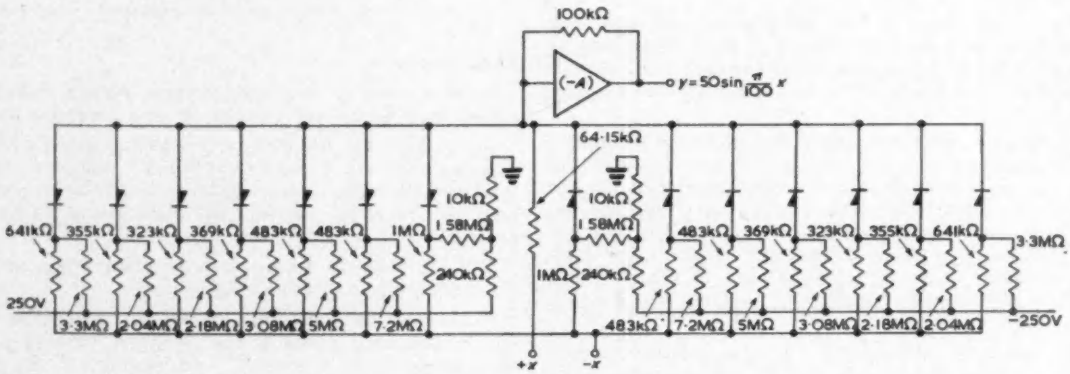


Fig. 6. Sine circuit (diodes are type ZS20A)

Sine Circuit

This circuit (see Fig. 6) was designed using conventional biased diode technique[3,4,5], and consists of a high-gain fed-back d.c. amplifier with a resistor-diode matrix as input impedance, containing 14 diodes.

This will generate:—

$$y = 50 \sin \pi/100 \cdot x$$

in the first and third quadrants with a maximum absolute error of 0·125V over any one segment, and requires two inputs $\pm x$. The minimum input impedance on the posi-

tive and negative terminals being 64kΩ and 34kΩ respectively.

Practical Circuit

This is shown in Fig. 7 and consists of the circuit previously described, with an additional amplifier to provide fine frequency control, by means of a ten-turn helical potentiometer on its input. This varies the input to the following integrator over a 10 to 1 range. A second phase-inverting amplifier is also added to provide sine circuit of the output amplifier, whose gain is controlled by RV_2. Thus a sine function of maximum amplitude 100V peak-to-peak is produced at the output terminal. Frequency range selection is achieved by S_2, which changes the integrator time-constant in five discrete steps. These are 25sec, 2·5sec, 250msec, 25msec and 2·5msec.

To produce ramp functions, diode MR_1 is connected in circuit and the integrator output is fed directly to the output amplifier, the phase invertor and sine circuit being

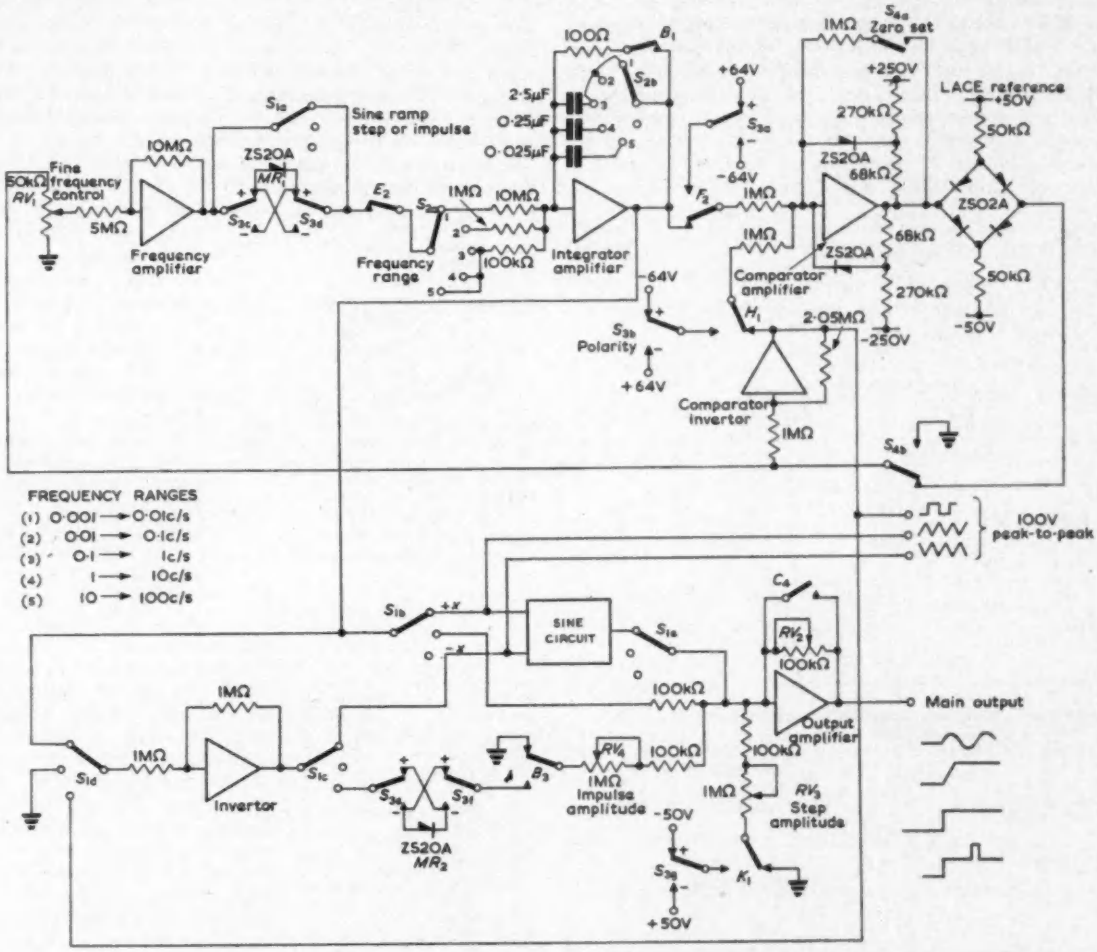


Fig. 7. LACE forcing function generator (practical circuit)

the negative input to the sine circuit and the impulse function to the output amplifier. The d.c. amplifiers are existing LACE printed circuit types and are not drift corrected. The zero potentiometers and outputs are brought out to the front panel, the latter on sockets, and the amplifiers are zero set in turn by plugging a voltmeter into the appropriate socket and operating S_4. This earths the comparator invertor and frequency amplifier inputs and connects a 1MΩ feedback resistor across the comparator.

Three modes of function selection are available, namely sine, ramp and step or impulse. With S_1 in the sine position the circuit behaves as described previously, the triangular waveform from the integrator being fed to the disconnected. As discussed previously, the action of MR_1 is to open-circuit the integrator input, producing a 'hold' condition when the first comparator transition occurs.

To generate a step plus impulse function, S_1 disconnects the integrator output and sine circuit from the output amplifier and connects the comparator to the output amplifier via invertor 2. On pressing the start button, contact K_1 connects the LACE ±50V reference to the output amplifier via potentiometer RV_3, which forms an independent gain control on this input. This action produces a step output. Then at some pre-determined time the operator presses the impulse button energizing relay F and activating the bistable device, which produces an impulse at the output of the com-

parator invertor. This signal is fed via diode MR_2 and gain control poteniometer RV_4 to the output amplifier. The diode ensures that the impulse is single sided with respect to the computing earth, by open-circuiting the line as the input waveform goes through zero volts. By operating only one of the control buttons, independent step and impulse functions can be obtained.

Control System

This circuit was designed to mate with the computer master control system, and is shown in Fig. 8. There are three control conditions available, namely, 'prime', 'start' and 'reset' corresponding to the computer conditions 'initial set', 'compute' and 'zero set'. A toggle switch labelled 'Lace/Local' is also incorporated to select the control mode. In the 'Lace' position, the computer 24V line is available for relay switching on bus bars Z, I/S and F, corresponding to LACE conditions 'zero set", 'initial set' and 'freeze'. These relays are operated manually by push-buttons on the generator front panel in the 'local' mode.

As a starting point consider the situation when the manual 'reset' button has been pressed. This action energizes relay C, which latches on via contacts C_3 and D_4 lighting the 'reset' lamp. This opens C_1 preventing relay K from operating, opens C_2 de-energizing relay B, and closes C_4 short-circuiting RV_2 in the output amplifier. Contact B_1 in turn short-circuits the integrator and B_2 connects the impulse input to the computing earth.

On pressing the 'prime' button, relay D is energized and latches through D_3, lighting the 'prime' lamp. This causes D_4 to drop out relay C, extinguishing the 'reset' lamp and opens D_1, keeping relay K de-energized. The closure of D_2 energizes relay H, which drops out after 15msec when slugged relay J operates. This momentary closure of H_1 ensures that the bistable circuit is in the correct state by switching prime voltage (−64V) to the comparator, producing −50V at the invertor output and +50V at the impulse input terminal.

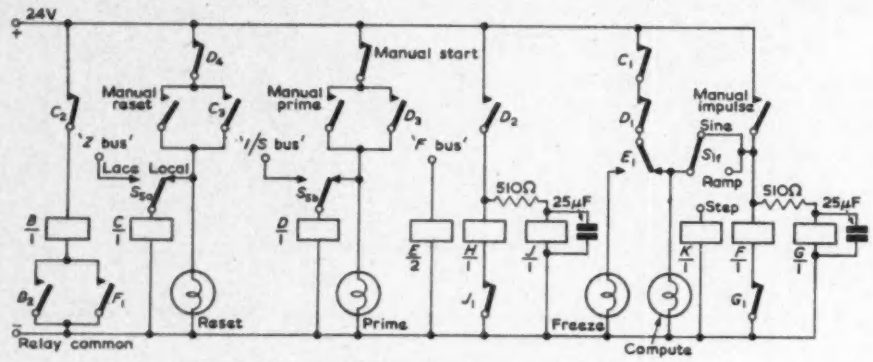


Fig. 8. Forcing function generator control circuit

To generate the step function, the 'start' button is now pressed. This de-energizes relay D, extinguishing the 'prime' lamp and dropping out relay J. The closure of D_1 then lights the 'compute' lamp and energizes relay K, whose contact K_1 switches the LACE reference voltage (−50V) to the output amplifier. A positive step therefore appears at its output terminal of amplitude set by RV_3. To generate the impulse function, where this may be delayed by an infinitely variable amount from the step, a manually operated push-button is incorporated for use in either control mode. When this is pressed, relay F is energized, which operates in the same manner as H, dropping out after 15msec. This causes F_1 to close, energizing relay B which latches via B_2. Contact B_1 then opens, removing the short-circuit from the integrator, and B_3 changes over, switching the impulse input from computing earth to signal input.

Simultaneously, F_2 closes momentarily, disconnecting the integrator and switching +64V to the comparator input. This produces a positive 100V step at the invertor output, which is fed as a negative 50V step via MR_2 to the output amplifier, and appears as a positive step at the output terminal, of amplitude deter-

TABLE 1

FUNCTION	OUTPUT TERMINAL	POLARITY	AMPLITUDE	FREQUENCY RANGE	FREQUENCY OR PERIOD	IMPULSE WIDTH
Sine	Main	+ or − *	0 to 50V semi-peak continuously variable	1 2 3 4 5	·001→·01c/s ·01→·1c/s ·1→1c/s 1→10c/s 10→100c/s	—
Ramp	Main	+ or −	0 to 50V cont. variable	1 2 3 4 5	250→25sec 25→2·5sec 2·5→·25sec ·25→·025sec ·025→·0025sec	—
Step	Main	+ or −	As ramp	—	Inoperative	—
Impulse	Main	+ or −	As step	1 to 5	—	As ramp
Step + impulse	Main	+ or −	Independent control on each. 0 to 50V cont. variable	1 to 5	—	As ramp
Triangle	Auxiliary	+ and − *	Fixed between ± 50V	1 2 3 4 5	1000→100sec 100→10sec 10→1sec 1→·1sec ·1→·01sec	
Square	Auxiliary	+ or − *	Fixed between ± 50V	1 to 5	As triangle	—

* *Polarity refers to that at the start of repetitive waveforms.*

mined by RV_4. This level is maintained until the integrator which has been producing a negative ramp reaches −50V, when the comparator 'flips over' disconnecting the integrator input and producing a 100V negative-going step at the invertor output. This appears at MR_2, which disconnects the signal as the waveform goes through zero volts and ensures that the output level falls to zero with negligible overshoot.

This impulse function may be repeated by simply repressing the button, but the device must be reset for further step functions. In addition to a combined step plus impulse function, both types can be generated independently. A freeze facility is also incorporated and operates in either control mode as follows.

If an overload occurs in the main computer then 24V appears on the F bus bar, which energizes relay E. Contact E_1 then changes over, extinguishing the 'compute' lamp and lighting the freeze lamp and E_2 open-circuits the integrator input, freezing the generator output.

A summary of the generator capability appears in Table 1.

Conclusions

A forcing function generator has been designed and built for analogue computer use, which will produce a variety of functions to an accuracy of ½ per cent full scale in frequency and amplitude. Frequency coverage is from 0·001c/s to 100c/s in five decade steps, with a 10 to 1 continuously variable fine control within each range. Flexibility has been achieved by basing the design on a triangular waveform generator feeding a biased diode sine circuit, and building this in modular form as a sub-unit, so that it can be replaced by another unit if and when the occasion demands.

The device may be controlled from the master computer or independently and has a built-in freeze facility which holds its output at a constant value whenever the main computer overloads.

Acknowledgments

The Author wishes to thank English Electric Aviation Ltd for their permission to publish this article.

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The Measurement of Flow Velocities

An electronic instrument known as a Constant Temperature Anemometer Flowmeter has been developed by Disa Electronik A/S of Denmark for the measurement of flow velocities.

The transducer element consists of a 1mm length of ·005mm diameter plated tungsten wire of very small diameter mounted on two supports of a probe which is inserted into the air stream whose rate of flow is to be measured. The wire itself is maintained at a constant temperature by the passage of an electric current.

When the probe is placed in the air stream there will be a heat loss in the wire due to convection and the principle of operation of the flowmeter consists of measuring the additional electrical power required to restore the temperature of the wire to its original value. The very small thermal capacity of the wire and the characteristics of the electronic system make it possible to measure instantaneous flow velocities up to frequencies in excess of 50kc/s.

The transducer is connected to one arm of a Wheatstone bridge as shown in the simplified diagram. A three decade resistance is included in the variable arm for initial balancing purposes.

The bridge is fed by a high gain d.c. amplifier whose output voltage is controlled by the amount of bridge unbalance. When the bridge is unbalanced by a change in resistance of the transducer element due to a change in its temperature which is itself brought about by the flow of air past the element, an unbalance voltage appears across the points a and c of the bridge.

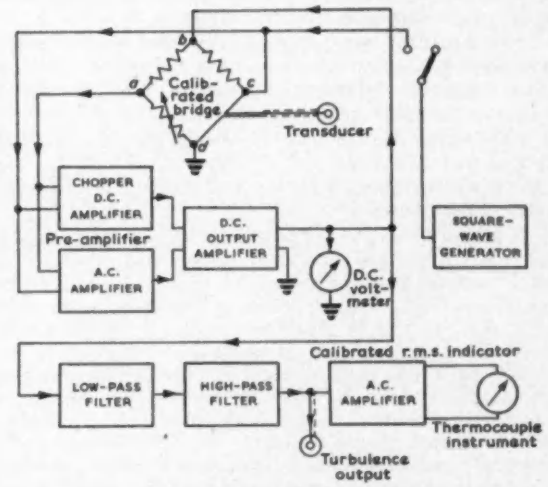
This voltage serves as the input to the amplifier which is so connected that a decrease in resistance of the transducer element will increase the supply voltage to the bridge. This will increase the power dissipated in the element, raise its temperature and tend to restore its resistance to its original value. It is thus possible to relate the mean velocity of flow to the bridge supply voltage.

Connected to the output of the d.c. amplifier is an a.c. amplifier and a thermocouple instrument, to enable r.m.s. values of turbulence to be obtained.

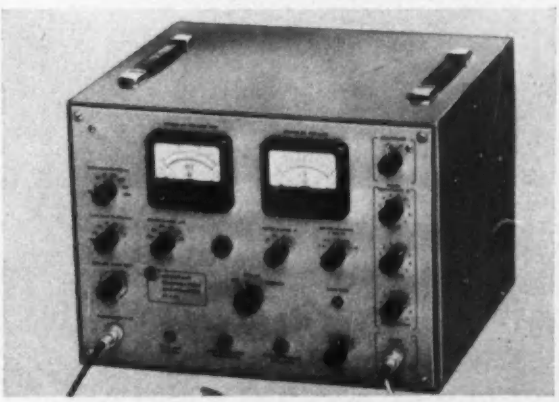
A square wave generator is incorporated in the flowmeter and allows the overall performance to be checked and the equivalent time-constant to be obtained at the conditions of flow.

With the wire type of transducer flow velocities ranging from a few centimetres per second up to a maximum of 150m/sec can be obtained.

For the measurement of air flow at supersonic speeds up to 500m/sec or for liquids up to speeds of 10m/sec the hot wire transducer is replaced by one in which the sensing element consists of a thin platinum foil fused on to a Pyrex glass support.



A simplified circuit of the flowmeter and (below) the complete instrument



A Satellite Tracking Station in Britain

RADIO equipment of a highly specialized nature has recently been installed at Winkfield in Berkshire as part of a world wide system for tracking satellites and for recording measurements of data telemetered from them.

The equipment, almost entirely of American origin, has been supplied on loan by the National Aeronautics and Space Administration (N.A.S.A.) and will be operated by staff from the Radio Research Station of the Department of Scientific and Industrial Research.

Until recently there were ten similar installations known as Minitrack stations, set up in North and South America at San Diego, Fort Myers, Blossom Point, Antigua, Quito, Lima, Antifagasta, Santiago; and at Johannesburg in South Africa and Woomera in Australia.

These stations were set up originally in positions of low latitudes to track satellites having orbits at comparatively small inclinations to the Equator.

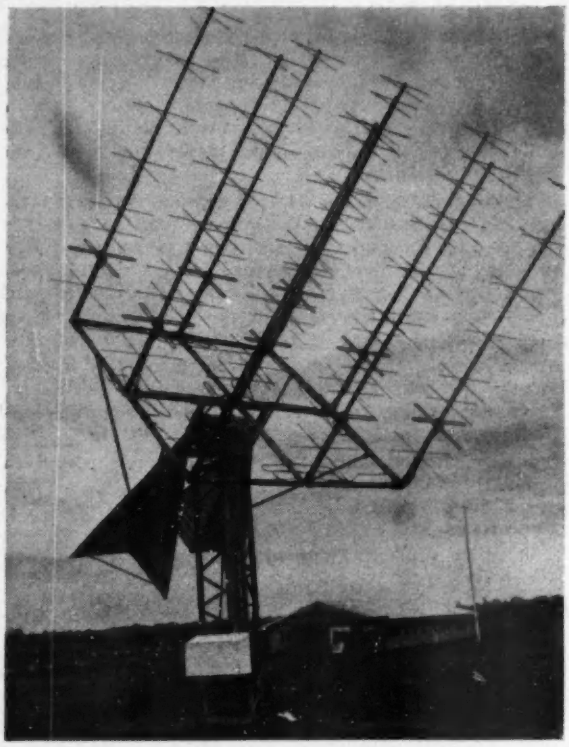
The Winkfield installation together with similar installations at Minnesota, Alaska and Newfoundland will form four additional Minitrack stations for satellites having orbits with higher inclination angles.

Information derived from the equipment—tracking and telemetered data from the satellites—is available for use by the Radio Research Station and in the general British space research effort.

A teleprinter circuit to the Goddard Space Flight Centre of N.A.S.A. is used to convey summarized results from each satellite transit observed at Winkfield. In the reverse direction up-to-date orbital information on all relevant satellites will be provided, and the Winkfield station alerted for new launches. Data is provided enabling the directional aerials used in receiving telemetry signals from the satellites to be correctly orientated. The teleprinter system also provides a link with other research centres in the United States, including the Smithsonian Astrophysical Observatory which analyses the optical observations on satellites obtained from precision cameras set up in various parts of the world. This facility will prove a valuable aid to the Slough headquarters of the Radio Research Station, which is also connected to the teleprinter circuit.

The Winkfield installation and its communication network will be of considerable value to the research effort in the two countries, particularly when British experiments are flown in satellites launched from Scout vehicles. Another example of the use of the Minitrack station will be the reception of the telemetered data from apparatus flown in satellites to investigate the upper portion of the ionosphere The Radio Research Station is to collaborate with American and Canadian scientists in two 'topside sounder' experiments of this kind by receiving the data at Winkfield and at its outstations at Singapore and in the Falkland Islands.

The installation at Winkfield has two separate functions —the determination of the direction of satellites as a function of time and the recording of telemetry data from satellites. It is designed to operate in the frequency band



The steerable telemetry aerial

136 to 137Mc/s although additional facilities are provided for telemetry at frequencies around 108Mc/s.

MINITRACK INTERFEROMETER SYSTEM

There are two separate interferometers. One (called the equatorial system) responds to signals arriving from a few degrees on either side of a vertical plane lying in the north-south direction and the other (the polar system) to signals arriving from a corresponding zone on either side of an east-west vertical plane. Switching arrangements are incorporated so that either aerial system can be selected for connexion to the receiver. For each interferometer the component aerials are accurately placed at the corners of a square whose diagonals are some 50 wavelengths long and are directed along the N.S. and E.W. directions. These aerials are called the 'fine' aerials since the phase difference between them varies rapidly with satellite direction and provides a correspondingly high acuity in directional observations. They are identical in construction, each comprising eight horizontal co-linear elements connected in phase with a tapered amplitude distribution. The arrays are mounted above horizontal ground screens each 50ft × 25ft in size and all arrays are in the same horizontal plane. The aerial arrays constituting the fine aerials of the equatorial system are arranged with the line of the component elements in the E.W. direction and those for the polar system lie in the N.S. direction. Thus each array has a vertically directed fan beam with a width between 3dB points of 11° in the H plane and 76° in the E plane. The pick-up polar diagram of each interferometer as a whole also has these characteristics since the fine aerials are all identical. It is necessary to have auxiliary aerials called 'ambiguity aerials', for measuring the integral number of 360° involved in the

phase difference between the fine aerials since the phase measuring equipment connected to these provides only the accurate value of the fractional part of 360°. The ambiguity aerials each consist of a single horizontal element mounted above an 18ft square ground screen and have a vertically directed pick-up polar diagram about 95° wide in both E and H planes.

All aerials are connected to the receivers by buried low-loss aluminium sheathed coaxial cables which are pressurized with dry nitrogen. The cables terminate in a console where remotely operated coaxial switches are located and serve to select either the polar or equatorial system for connexion to the receiver. For example, assume that the polar system has been selected. Then the cables from the following aerials are connected through to the receiver, North polar fine, South polar fine, East polar fine, West polar fine, and all five ambiguity aerials. To enable the direction of the satellite to be determinted the following six phase differences have to be measured: N.S. fine, E.W. fine, N.S. medium, N.S. coarse, E.W. medium and E.W. Coarse. The receiver has thus to be provided with six channels. These are identical in characteristics so only the process involved in the N.S. fine determination need be outlined by way of example. The signals from the N and S fine serials pass through separate pre-amplifiers and are then converted by frequency changers to intermediate frequencies differing from each other by precisely 100c/s. The beat oscillators are crystal-controlled and the 100c/s frequency difference required for the frequency conversion is phase-locked to a standard 100c/s voltage obtained from a precision 1Mc/s oscillator. Thus the original phase-difference between the N and S fine signal-frequency input voltages is represented by the phase of the 100c/s beat note at the output of the receiver channel relative to that of the 100c/s reference frequency. This phase difference is presented in two ways, as a d.c. analogue voltage and in digital form. In the latter case the two 100c/s voltages operate a gate system which counts the number of cycles of 100kc/s which fit in the time interval between corresponding points in the two 100c/s waveforms. Thus each 360° of 100c/s phase difference (and therefore of the signal frequency phase difference) is split into 1 000 parts and the digital display therefore has a phase discrimination of 0·36°.

The analogue and digital voltages (the latter in the form of a decimal code, read out five times a second) are applied to separate pen-type recorders, a separate stylus being used for each of the six receiver channels (that is, aerial combinations). Additional channels on the recorders are used for indicating time and to record the signal strength.

Facilities are provided to reference the phase-measuring system by injecting locally generated co-phasal voltages into the signal frequency pre-amplifiers. The receiver is crystal controlled and the operating frequency is selected remotely at the control console, 1 000 steps at 1kc/s intervals being provided in the frequency band 136 to 137Mc/s. The predetection bandwidth of each of the six main channels of the receiver is 10kc/s. An input of about −120dBm is required to give a reliable read-out on the digital phase meter, corresponding to an overhead range of about 1 500 miles on a 10mW transmitter.

Photographic Check

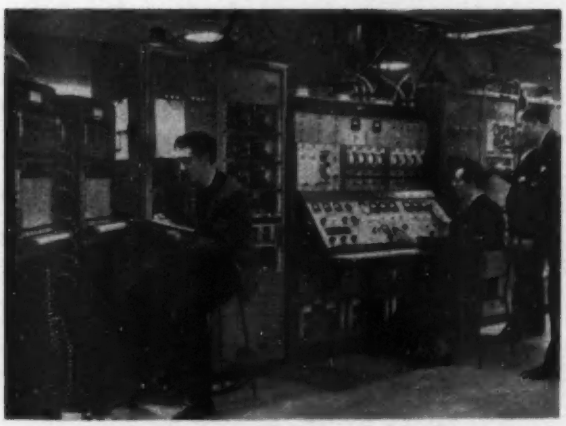
To check on the overall behaviour of the polar and equatorial interferometers as direction finders it is necessary to calibrate them from time to time. This is done by means of a high flying aircraft carrying a lamp which is switched on at known times, and photographing the track of the light against the star background which is used as a reference. At the instant the lamp is flashed on, the digital phase meter channels are recorded for the signal arriving from an extremely low power c.w. transmitter carried in the aircraft. Considerable directional acuity is provided by the interferometers; a change of 360° in phase difference between the fine aerials is produced by an angular movement from the zenith of about 1·2° and angular changes of one thousandth of this are potentially detectable on the digital phase meter. Thus high precision photography and timing accuracy are required. The camera used is permanently mounted on a polar axis at the centre of the system and driven so that star images remain stationary on the plate. The lamp on the aircraft is mounted at the centre of a downward pointing circularly polarized aerial which is fed by the transmitter operating on a frequency in the band 136 to 137Mc/s. The aircraft also carries a receiver which picks up coded timing signals from a ground transmitter for flashing on the aircraft lamp.

Telemetry Receiving System

The final 136 to 137Mc/s receiving system for telemetry has not yet been installed but experience has been gained, using signals on 108Mc/s from Explorer 8 launched last year.

The aerial consists of an arrangement of nine Yagi aerials in a 3 × 3 array; eight are used for reception, and the centre one is connected to a transmitter which is available when required for altering the operation of the satellite (for example, to cause it to transmit any recorded experimental data). Each Yagi is an assembly of crossed dipoles; thus from the receiving array two voltages are available, one corresponding to vertically polarized reception and the other to horizontal polarization. These two voltages are applied to low-noise pre-amplifiers at the base of the aerial system and the outputs are connected to the main building. Here arrangements are provided which permit the use of either of the two linear polarizations or the combination of the two voltages in phase quadrature so as to provide the equivalent of a circularly polarized receiving array. The single output from the combining unit is connected to the receiver input terminals. The whole aerial array can be orientated in any desired direction by remote control from the main building.

A general view of the Minitrack equipment showing (left to right) the phase recorder, phase measuring gear and standard frequency/timing rack. The telemetry receiving rack is on the extreme right



A Design Chart for Aerials with Parabolic Reflectors

By C. O. Titley*, A.M.I.E.E.

A parabolic reflector is one of which the inner reflecting surface has the form of the surface of revolution generated by rotation of a parabola about its axis of symmetry. Such a reflector has the unique property of producing radiation everywhere in phase over its aperture, when evenly illuminated by a point source at the focus. For this reason, parabolic mirrors find considerable application in radio and optics. The chart presented here was produced as an aid to design work on reflectors for radio aerials.

(Voir page 197 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 204)

Let A = aperture area of reflector (m²)
d = diameter (ft)
λ = wavelength of radiation (m)
f = frequency (Mc/s)
g = numerical gain of reflector
g_o = ideal numerical gain
G = gain (dB)
θ = beamwidth at half power points (deg)

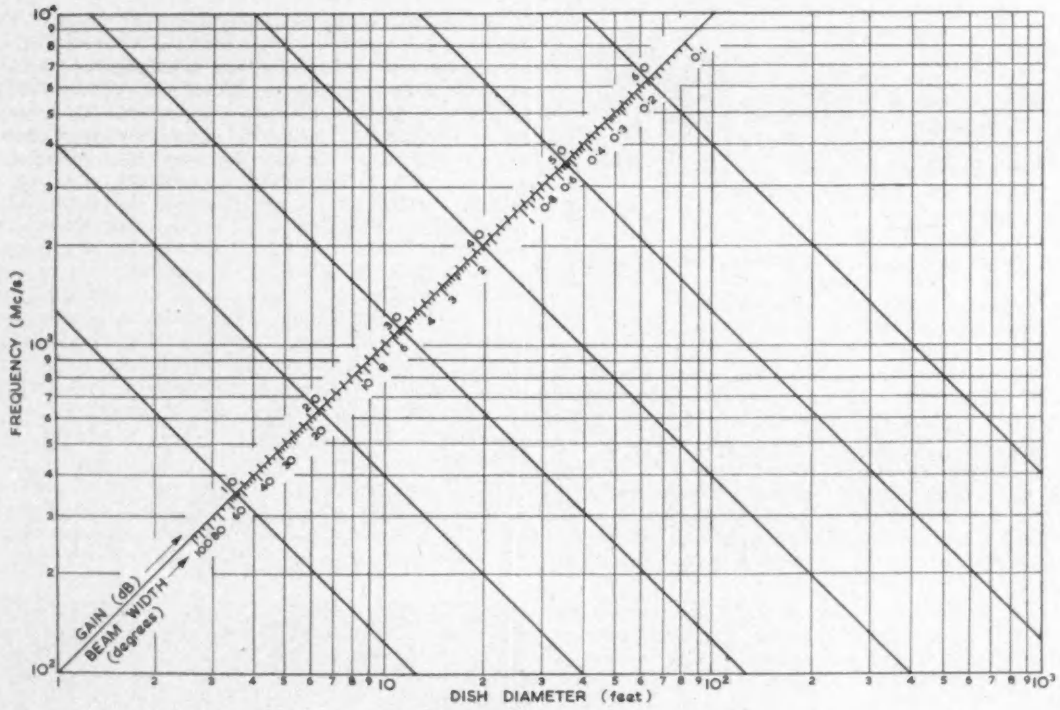


Fig. 1. Parabolic reflector design chart

In the ideal case of an aerial of large aperture compared with wavelength, and even illumination, it can be shown that, without approximation:

$$g_o = 4\pi A/\lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

The actual gain achieved in practice is related to the ideal gain by a dimensionless factor K, i.e.:

$$g = Kg_o \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

It is found that K is seldom less than 0·5 or greater than 0·75 and that a value representative of the majority of aerials is 0·6. This value has been used in construction of the chart. The error resulting from a factor of 0·5 or 0·75 instead of 0·6 is less than 1dB.

Thus:

$$g = 4\pi AK/\lambda^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Now: $A = \dfrac{(0{\cdot}3048)^2\pi d^2}{4}$

and: $\lambda = 300/f$

giving:

$$g = 6{\cdot}12 \times 10^{-6} f^2 d^2 \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$G = 10 \log g$$

i.e.:

$$G = 20 \log fd - 52 \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

It can also be shown that a very good approximation of the beam width is given by:

$$\theta^2 = 27\,000/g \quad \ldots\ldots\ldots\ldots\ldots \quad (6)$$

The Chart

The equation (5), for a specified value of G, may be

* *Sir W. G. Armstrong Whitworth Aircraft Ltd.*

plotted as a straight line using logarithmic axes for the parameters f and d. A series of values for G in 10dB steps gives the family of curves shown. Interpolation to 1dB is provided by the calibrated GAIN scale.

As shown by equation (6), beam width θ is a function of gain. A scale of logarithmic form giving beam width has been added below the GAIN scale, permitting direct conversion from GAIN to BEAM WIDTH and vice versa.

Use

A single line on the chart parallel to the family of lines through the 10dB points will give the relationship between dish DIAMETER and FREQUENCY for the value of gain at which it crosses the GAIN scale. At that point the BEAM WIDTH is given on the lower scale.

The frequency scale has not been extended beyond 10 000Mc/s. It will be clear that extrapolation for higher frequencies is readily possible by adding 20dB if the frequency is multiplied by 10.

Finally, if it is known that the 'efficiency' factor K is other than 0·6 a correction to the value of gain given by the chart may be made by adding:

$$10 \log (K/0{\cdot}6)\ \text{dB}$$

The Commonwealth Trans-Pacific Telephone Cable

Orders have now been placed for the 8 700 nautical miles of newly developed submarine telephone cable and 335 submerged amplifiers required for the largest telephone cable project yet undertaken—the Commonwealth submarine telephone cable, which will span the Pacific linking Australia, New Zealand and Canada.

The Pacific telephone cable is being undertaken jointly by the United Kingdom, Canada, New Zealand and Australia. Control of the project has been vested in a Management Committee comprising one senior representative each from the Overseas Telecommunications Commission (Australia), Cable and Wireless Limited, the United Kingdom Post Office, the Canadian Overseas Telecommunication Corporation and the New Zealand Post Office.

The orders for the cable and submerged repeaters (amplifiers) have been placed by the Management Committee with Standard Telephones and Cables Ltd, and Submarine Cables Ltd, both of the United Kingdom. The total value of the orders is approximately £18m. Under the conditions of contract, as much as possible of the raw material required for the cable is to be supplied from Australia and Canada.

The programme for the Pacific cable project provides for the Sydney-Auckland section being laid first and made ready for service by July 1962. Work has commenced on the terminal installations in Sydney and Auckland. Completion of the trans-Pacific cable as a whole is scheduled for mid-1964. The cable will have a capacity of 80 high grade telephone channels. In addition to public telephone service it will provide public telegraph, phototelegraph, and telex circuits together with facilities for leased private circuits for all types of telecommunications services and broadcast programme channels. It will connect, via Canada, with a similar cable to be laid this year between Canada and the United Kingdom, and will thus open up greatly expanded capacity and improved services between Europe and New Zealand and Australia.

The Atlantic and Pacific telephone cables represent the first two major links in the round-the-world Commonwealth Telephone cable scheme which was recommended by the Commonwealth Telecommunications Conference in 1958, and has been approved in principle by the Commonwealth Governments. Individual links are being built as and when it is possible to finance and engineer them on a partnership basis between Commonwealth countries.

Standard Telephones & Cables Ltd will supply 2 800 nautical miles of submarine cable, 242 submerged repeaters and 38 submerged repeaters while Submarine Cables Ltd will supply 5 875 miles of cable, 93 repeaters and the deep sea housings for 335 repeaters.

As most of the cable will be laid in deep water (2 000 to 3 500 fathoms), the United Kingdom Post Office type of 'lightweight' cable will be used for all but 270 nautical miles of the route. This cable is not armoured and its design departs from previous practice in that it has a non-twisting steel core as the main tensile component. This core is surrounded by a copper tube to form the centre conductor which is then insulated with polythene to a diameter of 0·99in.

The outer conductor is formed from aluminium tapes which are then wrapped with polythene and further tapes added for screening. Finally an anti-corrosion tape and an outer polythene sheath are added: this brings the overall diameter to 1·30in.

The conventional type of cable has a tendency to transmit torsion to the repeaters during laying, with consequent hazards to the repeaters, whereas the torsion-free lightweight cable does not have this disadvantage. It thus enables repeaters to be laid at greater depths.

The submerged repeaters will be inserted in the cable at intervals of about 26 miles. Each repeater consists of an amplifier, which amplifies all the conversations simultaneously in both directions, together with other electrical units such as filters, equalizer and supervisory apparatus. Over 300 electrical components are assembled in brass or copper containers to form in all about eight units which are mounted in a framework of Perspex bars and enclosed in a thick steel-tube housing capable of withstanding sea-bottom pressures up to 5 to 6 tons per square inch.

The two ends of lightweight cable which have to enter a repeater are armoured for a few fathoms each side of the repeater so that the tension in the central strand may be transferred through the various layers of tapes and polythene to the armour wires. These armour wires (or the armour wires of the conventional armoured cable used in shallow water) are anchored in special clamps attached to each end of the housing. Carefully machined bulkheads are brazed into each end of the housing proper; thus the brass inner tube does not have to withstand sea pressure. The outer-conductor tapes are terminated on the bulkheads while the inner conductors pass through a special gland which forms an integral part of each bulkhead. These glands are also, of course, capable of withstanding the full sea pressure. The completed repeater is about 10 feet long, 10¼ inches in diameter and weighs half a ton. Extreme care is taken throughout all stages of production of a repeater with the expectation that it will continue to give service, undisturbed on the ocean bed, for at least 20 years.

A 500ft Aerial Tower for London

For some time now the Post Office has been faced with the risk of obstruction to television links and public telephone services from the high buildings already built and planned in London.

These services are going to depend more and more on microwave radio links, which require a clear line of sight from point to point, and high buildings on this line can break the link. Therefore, a high tower is essential.

To overcome the problem and keep abreast of the current trend for increasing building heights, the Post Office plans to build a 500ft tower at the Museum Exchange in Howland Street, London, W.1, to replace the radio mast on the existing building which gives an effective height of only 180ft. At Museum Exchange is located the switching centre for the interconnexion of outlets from London to the existing national radio and television network in the London area and the BBC and ITA transmitters and from numerous television studios in the London area. It is also the London focal point for microwave radio links over which more and more trunk telephone traffic is being carried instead of by underground cables.

Believing that the new tower, which will be of modern design, will be an addition to the amenities of London, the Post Office is providing a public observation platform at a height of about 460ft. This will be reached by high speed lifts, which, travelling at about eight miles an hour, will take some 40 seconds on the journey.

ELECTROLUMINESCENCE
Its Characteristics and Applications

By D. H. Smith*, M.Sc., Ph.D., A.M.I.E.E.

(Part 2)

(Voir page 128 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 135)

The Cell as a Source of Illumination

ELECTROLUMINESCENT lamps, first produced in 1950, are very similar to the experimental cells described in Part 1, and shown in Fig. 2. They are more rugged in construction and may have an extra layer of a material which has a high dielectric strength and high dielectric constant. This is usually a dense suspension of powdered barium titanate in a plastic binder, and has the additional advantage of reflecting almost all the light which is emitted 'backwards' from the phosphor. The thickness must be very uniform in order to obtain uniform brightness over the whole area of the lamp. Also, because the electric field-strength in the regions of the individual crystals in which emission is occurring is close to the breakdown value, only small variations in the average field-strength (and hence in the thickness of the cell) can be tolerated. Because of this limitation, electroluminescent panel lamps are restricted in size to about 12 to 15 inches square. However experimental panels as large as 24in × 30in have been made successfully. Finally the panels must be made moisture-proof by some form of encapsulation or sealing. A panel which is left open to the atmosphere deteriorates rapidly and the brightness may fall by 50 per cent after less than 100 hours of operation.

With all panel lamps, however well they are sealed there is a gradual variation of brightness throughout their lifetime. As Fig. 17 shows the brightness increases for the first few hundred hours and then decreases for the rest of its useful life. It is a feature of these lamps that they do not fail suddenly through breakdown, but they have to be replaced when the light output has fallen to some arbitrary value. The rate of decrease depends on the voltage and frequency of operation. For a lamp operated at 50c/s it may take over 20 000 hours for the brightness to drop to 75 per cent of its initial value. This figure compares very well with the 8 000 hours sometimes quoted for modern fluorescent tubes.

An improved construction has been developed recently, in which the phosphor-dielectric layer is applied to a flat ceramic-covered metal base. A very thin sheet of glass is fused to the surface to seal and protect the phosphor. The total thickness is less than one fiftieth of an inch.

The brightness and efficiency of electroluminescent lamps do not yet compare very favourably with those of other sources of illumination. The brightness is about 10ft-lamberts when operated directly from the 50c/s mains, and if a special 4kc/s supply is used a brightness of 180ft-lamberts can be obtained. The significance of these figures can be appreciated from the estimated requirement of a brightness of 50 to 100ft-lamberts if a living room is to be illuminated by means of a ceiling consisting entirely of luminescent panels! The efficiency in terms of light output per watt of electrical energy is (at 50c/s) only about half that of a 100W filament lamp. It increases as the frequency is raised but the best obtainable efficiency is much less than that of a fluorescent tube. Ceiling panels and wall panels have been demonstrated but have not been manufactured on a commercial basis. However there are some specialized applications for which electroluminescent panels are particularly suitable. Examples are, safelights of various colours for use in darkrooms, radio dials, aircraft instrument lighting, 'exit' signs in cinemas, and indicator panels for lifts. At the low levels of illumination required for some of these applications the panels, if operated continuously for a year, would consume less than one unit of electricity.

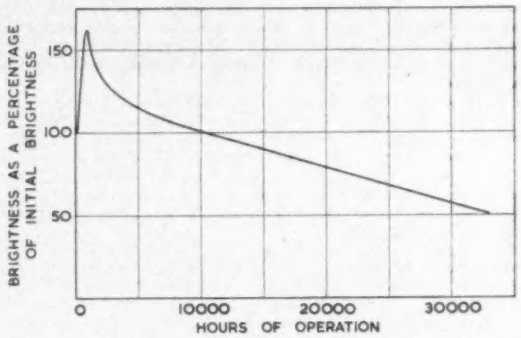


Fig. 17. Ageing of an electroluminescent lamp *(by Wylie)*

Information Display Systems

Electroluminescence has many advantages in displays of numerical and symbolic information, especially where characters are formed by separately illuminated segments. Such displays are used, for example, in control rooms on airfields, or military operations rooms, where up-to-date information on the availability of aircraft, vehicles, etc., is required. They may also be found useful in applications as diverse as train indicators, stock quotation boards, and digital voltmeters. The electroluminescent panel is thin and it forms a flat indicator which can be read over a very wide viewing angle. All the light generated is useful so that the effective efficiency is greater than with other types of indicator (such as filament bulbs with masks over them). The panels do not require evacuated envelopes or heated filaments, and they do not reach a high temperature, so the possibility of failure is very small. They can be made in a wide range of sizes, from a fraction of an inch to several feet in height, and the brightness is more than sufficient for use in an adequately-illuminated room.

One system developed recently uses combinations of some or all of nine narrow vertical or horizontal segments to make up the decimal numerals 0 to 9. This is illustrated in Fig. 18, the centre of which shows an electroluminescent cell with a large area transparent front electrode, and a back electrode divided into nine segments.

* *Naval Research Laboratory, New Zealand.*

To display a '9' for example, all the segments except the one labelled 'e' must be selected. They are connected together to one side of an alternating voltage source, the other side being taken to the transparent electrode. The smaller diagrams in Fig. 18 show the shapes of the numerals which can be obtained. Some of these are rather unconventional, but they satisfy the essential condition—that they should be clearly distinguishable from one another.

In another system, illustrated in Fig. 19, 14 segments, four of them diagonals, are used. All the letters and numbers, as well as some other useful symbols can be simulated by combinations of these. This system has been described as an 'Electroluminescent Typewriter' because a conventional typewriter key-board is used for the selection of the required character. When a character has been selected it will remain illuminated until it is altered by the selection of a different one, or is extinguished by operation of the 'erase' key. The simultaneous selection of all the segments which form a letter, by means of a single key, involves some rather complex switching. This is performed by decoding or 'translation' matrices using crystal diodes or ferro-electric switches. The whole equipment therefore uses only solid-state devices, without any need for thermionic valves and their associated power supplies.

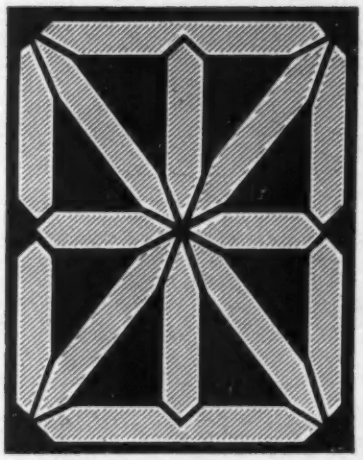


Fig. 19. Combination of 14 segments gives numbers or letters (*by Hamburger*)

Graphical Output Unit for a Digital Computer

The results of calculations made on a digital computer appear at the output in numerical form, but in many cases it is desirable to display them graphically. An electroluminescent matrix is particularly suitable for such an application. The matrix, consisting of say $n \times n$ small cells, is analogous to a sheet of graph paper with $n \times n$ squares. This is illustrated by Fig. 20 which shows a 32×32 matrix, with all the cells luminescing. One 'draws a curve' on the matrix by illuminating successively the cells corresponding to the points calculated by the computer. For example if the computer plots a straight line at 45° to the axis, going through the origin, the cells along the diagonal of the matrix will be illuminated in succession. The curve can be recorded photographically as well as being inspected visually. An electroluminescent display of this type has some advantages over graphical-output units using cathode-ray tubes. Selected points are fixed in position, whereas with a c.r.t. the position is subject to small variations in the deflexion sensitivity. Also the output from the computer is in digital form, which is ideal for the selection of points on the matrix; to produce deflexions on a c.r.t. it must be converted to analogue form, and this introduces another source of error.

THE ELECTROLUMINESCENT MATRIX

The matrix of electroluminescent cells is made by a photo-etching process which enables high accuracy of positioning and uniformity to be achieved. The n^2 cells are the intersections formed by two sets of n long narrow conductors at right-angles to each other. One set of course must be transparent. A phosphor layer of large area is sandwiched between the two sets of electrodes, as shown in Fig. 21. Each intersection forms an electroluminescent cell identical in properties to the cells discussed in Part 1. Matrices have been made with 512 lines in each direc-

Fig. 18. Use of nine-segment pattern gives any number from zero to nine (*by Lyman and Jones*)

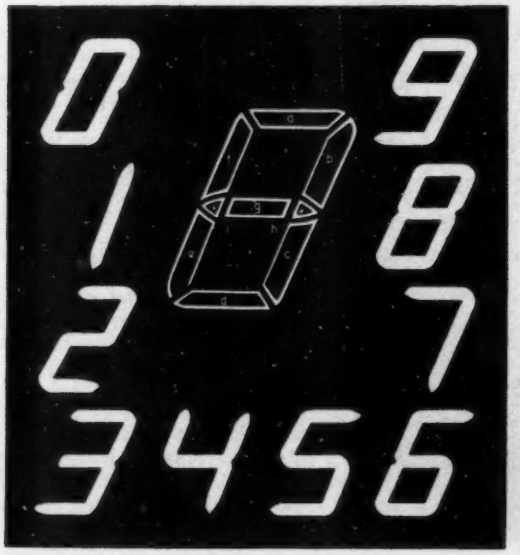
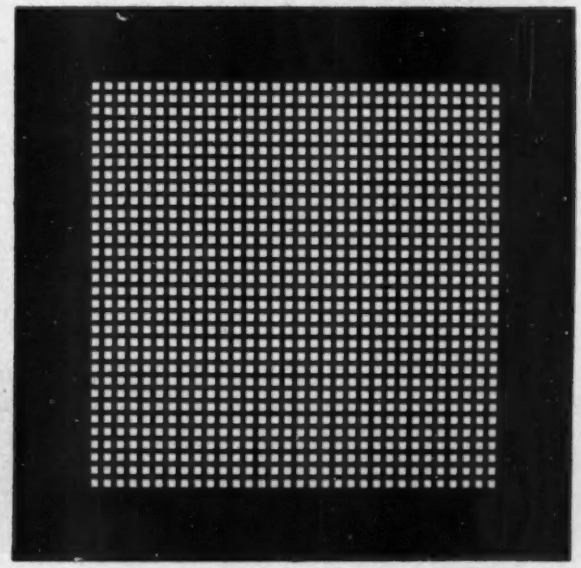


Fig. 20. Electroluminescent matrix luminescing



tion, each line (conductor) being 0·015in wide, and separated from its nearest neighbours by ·005in. The problem of making electrical connexion to the conductors is solved by providing for each a small silver 'flag' to which leads can be soldered. The way in which this is done can best be illustrated by the photograph of a 128 × 128 array shown in Fig. 22.

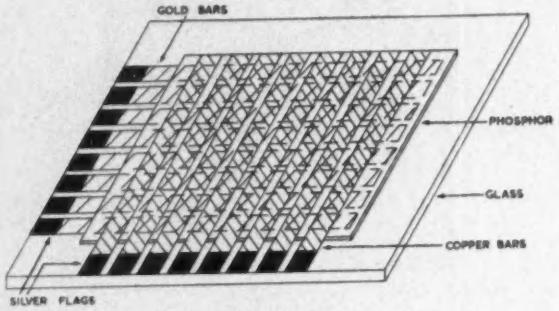


Fig. 21. Electroluminescent matrix

To make any selected cell luminesce an alternating potential must be applied to the appropriate two conductors, one vertical and one horizontal. It is usual to earth all the unselected conductors, and to apply equal anti-phased voltages to the two selected. Thus if a peak-to-peak voltage of $+v/2$ is applied to the selected horizontal line, and $-v/2$ to the selected vertical line, the selected cell will have a voltage of v across it (Fig. 23). In addition all the other cells along the selected lines (a total of $2n-2$) will have voltages of $v/2$ across them. They also will luminesce, but with a lower intensity. The ratio of the brightness of the selected cell to that of these (unwanted) cells may be called the discrimination ratio. In this graphical output application the photographic film recording the selected cells is continuously exposed to the emission from the unwanted cell positions. Images at these positions will gradually build up as the points on the required curve are selected one by one. The discrimination ratio gives an

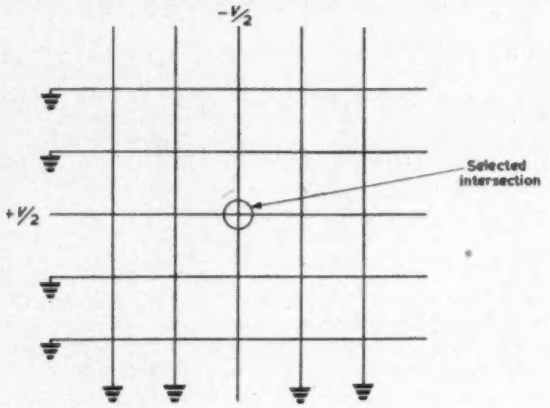


Fig. 23. Selection of a cell in an electroluminescent matrix

indication of the number of points which can be selected before a background of unwanted images becomes apparent. It is evident that the ratio should be as high as possible.

The brightness B of the emission from a selected cell depends on the voltage across it in a way specified by the equation (given in Part 1):

$$B = a.\ \exp(-\ b/\sqrt{v}) \quad \ldots\ (1)$$

Thus the discrimination ratio D, as defined above will be given by:

$$D = \exp(0{\cdot}414b/\sqrt{v}) \quad \ldots\ (2)$$

This shows that D increases as the voltage (and hence the brightness) is lowered. A considerable increase in the discrimination ratio is obtained when the unselected conductors, instead of being earthed, are energized with an anti-phase voltage one third of the amplitude of that applied to the selected conductor. This method of selection is shown in Fig. 24. In this case, when a voltage v appears across the selected cell, all the $n^2 - 1$ unselected cells have voltages of $v/3$ across them. The new discrimination ratio, D' is

$$D' = \exp(0{\cdot}732b/\sqrt{v}) \quad \ldots\ (3)$$

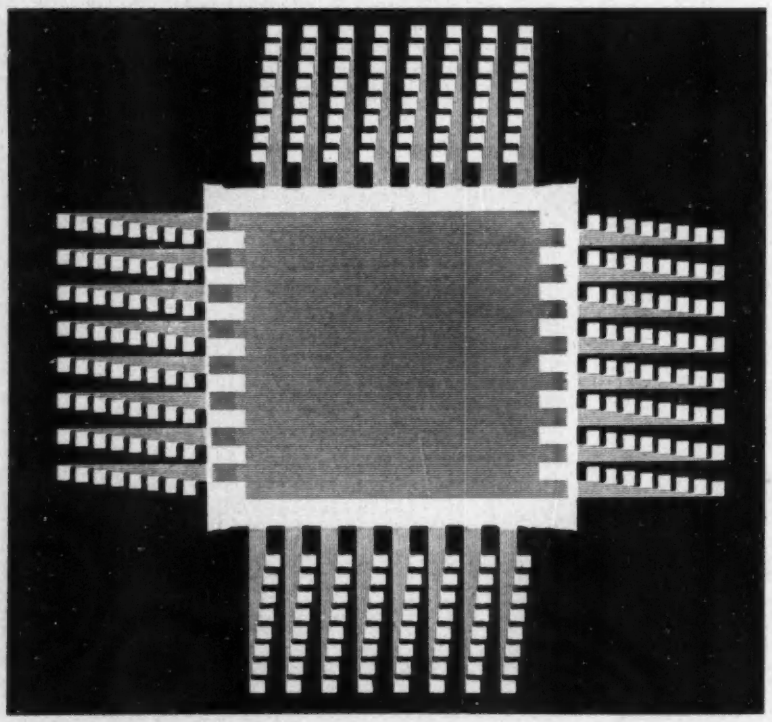
In typical operating conditions it has been found that the following values may be obtained:

$$D = 600$$

$$D' = 80\,000$$

In addition to this great increase in discrimination, the second method has the advantage that all the unselected cells will give images of equal intensity—the

Fig. 22. 128 × 128 matrix



background will not depend on the shape of the curve(s) being plotted.

Computers operate at high speeds and it is important that the time taken to record each point on a curve is not so great that computer time is being wasted. The minimum time for which a selected cell must be energized is affected by the value of v—if v is increased then the excitation time can be reduced. It is affected also by the build-up phenomenon, since under normal operating conditions the time interval between successive selections of any given point on the matrix will vary within very wide limits. Thus the excitation time should be sufficient for the build-up to have a negligible effect on the total emission from a selected spot. It is further influenced by the fact that the characteristics of photographic emulsion can be used to improve the discrimination by a factor of 10. This is because for very low light intensities the 'reciprocity' law relating illumination intensity with

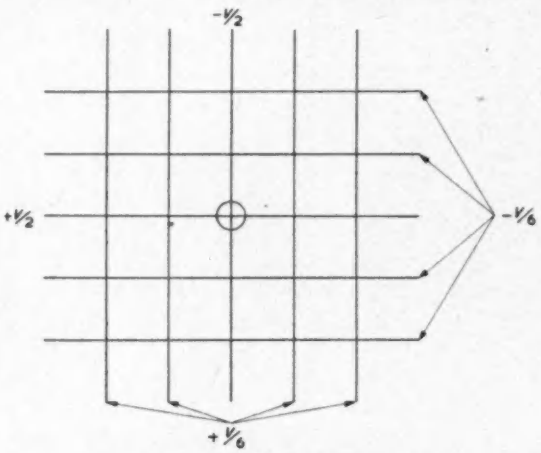


Fig. 24. Improved method of selection

the exposure time fails. Clearly it is possible to sacrifice speed of operation for a greater discrimination ratio, or vice versa, and a compromise must be reached. With the 512 × 512 panels now being tested on the 'Mercury' computer at Manchester University it is expected that a satisfactory discrimination ratio, and a sufficiently dense photographic negative can be obtained by choosing v = 150V, and energizing the cell for a few milliseconds.

Electroluminescent Matrix as a Permanent Store

Information stored in the high-speed store of a digital computer may be of two types, namely that which is retained during one or more operations involving a comparatively small total time and that which is required throughout prolonged sequences of operations. It is desirable that the latter kind of information be permanently stored so that it is readily accessible at any time. In view of the limited capacity of the high-speed store it is an advantage to have a subsidiary store for this kind of information. It is desirable that the information in such a store should be accessible at high speed and that reading the information should be 'non-destructive.' These requirements can be met by a storage device based on the phenomena of electroluminescence.

The information to be stored will contain both numbers and instructions, but all of it is coded in 'binary' form before being transferred to the high-speed store. This means that the 'information' consists only of '0's and '1's. A simple form of store uses a matrix of $n \times n$ electroluminescent cells, covered by a mask which has holes to indicate '1's and is opaque where '0's are stored. Photographic masks of the type shown in Fig. 25, having the required pattern of information, can be made with high accuracy. The information can be changed, if necessary, by changing the mask. It can be read out by selecting the cells one at a time (by means of voltage pulses applied to the appropriate vertical and horizontal conductors), and detecting the resulting light flashes with a photo-multiplier.

The method of operation of the matrix is essentially different from that used in the graphical output panel. In order to read the stored information rapidly it is necessary to energize the cells with very narrow pulses of voltage; this leads to the emission of double pulses of light which may rise to a maximum in 0·2μsec or less. The emission decays relatively slowly and, depending on a number of factors, may take from 15 to 50μsec to decay to one-tenth of its maximum. It is this 'afterglow' which limits the rate at which digits can be read. When a number of cells is selected in succession the photo-multiplier is, at any given time, able to detect light from the cell which has just been selected, and also from any others

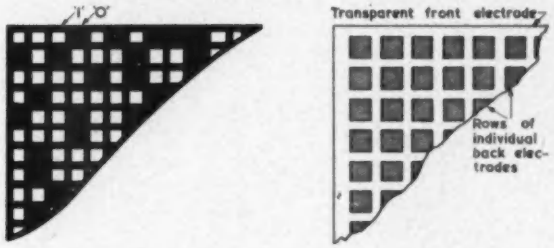


Fig. 25. (left) Part of a typical mask (*by Hoffman et al.*)
Fig. 26. (right) Section of television panel

which have been selected previously and are still luminescing. The digit period must be made long enough to ensure that the residual emission from all previously-selected cells is much less than the emission from a selected '1'.

One of the attractive features about an electroluminescent matrix as a store, is that it may be possible to use matrices containing a large number of very small elements. 32 × 32 matrices with cells 1mm square have been operated successfully, and the probable limit to the size of the cells is about 0·25mm square. However, because of the limit to the sensitivity of the photo-multiplier the choice of a smaller size of cell necessitates the use of larger voltage pulses. The total number of cells that can be tolerated in a matrix is limited by the discrimination, which in turn is decreased by the use of larger pulses, so a compromise has to be made. Discrimination has a definition which is different from that used in the previous section. The problem now is to discriminate (in the extreme case) between the light pulse obtained when a '1' is selected from a matrix in which all the non-selected elements are '0s' and the pulse which occurs when a '0' is selected in a matrix which has (n^2-1) '1's.

An equation similar to (1) relates the amplitude of the light pulse with the amplitude of the energizing voltage pulse. This equation can be used to find the amplitude of the anti-phase voltage which when applied to the non-selected conductors will give the best discrimination ratio. From it also the maximum number of cells which can be tolerated in the matrix, if an arbitrarily-chosen value of the discrimination ratio is to be achieved, can be calculated. These quantities are primarily dependent on the

term $b/\sqrt{v}$ which appears in equation (1) and for typical operating conditions when narrow pulses of voltage are used, this has a value of about 11 or 12. With this value, the calculations suggest that it should be possible for a 64 × 64 matrix to be used (this may be compared with the normal size of 32 × 32 for a magnetic-core store). However measurements on experimental panels give lower values of discrimination ratio, and show that the maximum size is about 32 × 32. The lower discrimination is caused by the light emission from a '0' being enhanced by light which has been totally reflected at the glass surface and then scattered forward again by the phosphor. Some of this scattered light escapes through holes in the mask ('1's) and reaches the photo-multiplier. This effect could be minimized by using very thin sheets of glass for the panels.

Possible advantages of using an electroluminescent matrix as a store are:

(a) Each element can be made very small so that relatively large numbers of digits can be stored in a small area.

(b) The method of construction is suitable for the production of cells which are very uniform at a relatively low cost.

(c) The read-out is rapid and is obtained in the form of a pulse of light. This can be expected to simplify pick-up problems.

Thin-Screen Television

With the production in the early nineteen fifties of the first large-area electroluminescent panels came the realization that it might be possible to produce television sets using flat viewing screens. The popular conception is of large thin screens which can be hung on the wall. A simple electroluminescent matrix is unlikely to be used for this application because of the difficulty of selecting any one cell without affecting some or all of the others. The panel is likely to have a single large-area transparent 'front' electrode, and a large number of small 'back' electrodes (Fig. 26). This would give a regular array of discrete cells, each of which is energized by a voltage which produces the intensity of light required at its location. A screen of this type, used to produce images in response to video signals, differs from the conventional cathode-ray tube in several important ways. For example it is flat, it needs no evacuated envelope, and it is operated by digital instead of analogue scanning. Images very much larger than those of present-day television tubes can be contemplated. There are, of course, problems to be overcome before electroluminescent screens can be made with resolution, contrast, brightness and lack of flicker, equal to those of the c.r.t. The fundamental difficulty is that in order to obtain satisfactory resolution the number of cells required is of the order of a quarter of a million, and if these are scanned sequentially, then each one can have a control voltage applied for only a few millionths of the total time. If the total scan time is 0·05sec (i.e. the 'frame' frequency is 20c/s) then each cell is energized for 0·2μsec, twenty times per second. An electroluminescent cell operated under these conditions has a very low average brightness. Indeed it seems essential that each cell should emit light continuously at a brightness level set by the video signal, and should continue to do so until a subsequent video signal alters the level. In other words for each cell there should be a means of storing the information in the video signal for 1 scan period, and of energizing the cell according to this stored information. There must also be a scanning mechanism by which video information can be passed to each element in turn.

One suggested method of meeting these requirements uses a magnetic storage device. Each element of the array of electroluminescent cells has associated with it a 'transfluxor'. The transfluxor illustrated in Fig. 27, may be described as a special type of saturable transformer in which the mutual inductance between two windings is controlled by pulses applied to a third winding. The energizing a.c. is applied to the primary of the two 'controlled' windings and the secondary is connected directly to the electroluminescent cell. The special features which make the transfluxor suitable for this application are:

(1) A very narrow pulse (0·5μsec) can set the mutual inductance at a value at which it will remain indefinitely until the next control pulse arrives.

(2) If a number of transfluxors is arranged in the form of a matrix, then any individual one can be operated by the application of half-amplitude pulses to the appropriate row and column. The other elements along the selected row and column (which receive a single half-amplitude pulse) are unaffected.

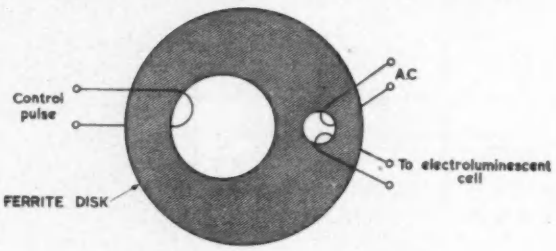


Fig. 27. The transfluxor (*by Rajchmann*)

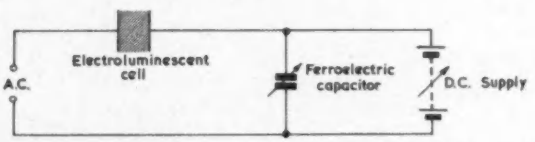


Fig. 28. Ferroelectric control of an electroluminescent cell (*by Sack*)

An array containing 1 200 electroluminescent cells and transfluxors has been tested on a closed circuit television system and has given satisfactory brightness and contrast. A repetition rate (or frame frequency) of 15 per second was found to be sufficient to give the illusion of continuous movement without any noticeable flicker. The control pulse for each cell was obtained by sampling the video signal at the instant that the cell was selected.

The cost of providing a transfluxor for every cell in the electroluminescent array makes an array of a quarter of a million completely uneconomical. Development is proceeding and it is likely to be aimed at providing the necessary storage with fewer components. A possibility is that the cells may be selected a line at a time, so that only a single row of transfluxors is used. This has the obvious disadvantage that the cells are excited for only the period of a row scan, but with the improvement which may be expected in the making of phosphors, it may provide an acceptable solution.

A second method uses a ferroelectric element to give storage and control. Ferroelectric materials—such as barium titanate—have the property that their capacitances can be altered by the application of a d.c. potential. The greater the potential, the lower the capacitance becomes. If an alternating voltage is used to energize an electroluminescent cell in series with a ferroelectric capacitor, as

in Fig. 28, then the voltage across the cell—and hence its brightness—can be controlled by a d.c. bias applied to the capacitor. Furthermore if the bias is removed the capacitor will store its charge for a period of at least several minutes, so the brightness of the cell will remain unchanged until another control signal is applied. These ferroelectric capacitors can be incorporated in the electroluminescent screen, though a rather complex structure results. Multi-element screens with 10 elements to the inch have been made and there is no fundamental reason why, with improved techniques, resolutions of 50 to the inch should not be obtained.

A possible method of distributing the video information (i.e. the control signals) is to make use of a set of intermediate storage cells, one for each element in a line of the screen. The video information is written into this store as it is received, and when the store is full the information (in the form of a quantity of electric charge) is transferred simultaneously to all the ferroelectric elements in one line. The next batch of video information

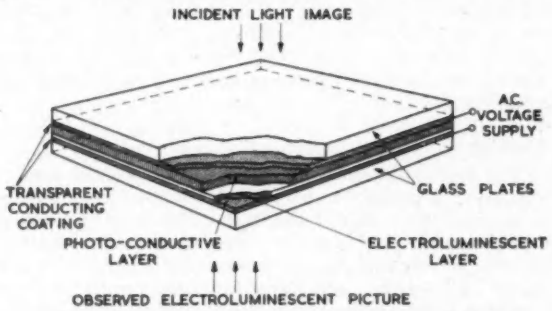


Fig. 29. Sandwich type light amplifier (*by Kazan and Nicoll*)

is then written into the store, and in its turn is transferred to the next line on the screen. It is claimed that with this method control signals can be distributed at megacycle rates, and it is worthy of note that there is no interruption to the emission from the electroluminescent cells.

This type of screen gives the necessary brightness, contrast, and half-tone reproduction, and can almost certainly be developed to the stage where the resolution and the speed of distribution of the video information are adequate. The problems awaiting solution are concerned with the economical fabrication of the screen and the associated scanning system. To what extent these problems can be solved it is difficult to say, but one is bound to be optimistic in view of the tremendous advances being made in so many branches of solid-state physics.

The Light Amplifier

A light amplifier, or image intensifier, is a device which when receiving light of a given intensity from an object, is capable of producing a brighter image of the same size. The most successful solid-state light amplifiers use a combination of photo-conductive and electroluminescent elements and give gains of 100 and more. The gain is a function of both the wavelength and the intensity of the incident light and is generally greater for lower intensities. The colour of the image is always the characteristic colour of the electroluminescent emission. This depends on the phosphor used and it is possible to have blue, green, yellow, red, or a mixture of these. A simple light amplifier can be made by sandwiching a thin layer of photoconductive cadmium sulphide and a thin layer of phosphor between two transparent conducting electrodes, as shown in Fig. 29. When an alternating voltage is applied to the electrodes the magnitude of the current will be controlled by the total impedance of the two layers, which are electrically in series. If the intensity of the incident illumination increases, the resistance of the cadmium sulphide will decrease. This will result in a larger fraction of the voltage being dropped across the phosphor layer and an increase in the brightness of the emission. The realization of a high gain is dependent on the correct matching of the impedances of the two elements and for this reason the simple sandwich-type of structure is not very satisfactory. The incident light cannot penetrate far into the cadmium sulphide so, to obtain a large change in the resistance, a thin layer must be used. But a thin layer will have a capacitance which is high compared with that of the electroluminescent layer, so that even

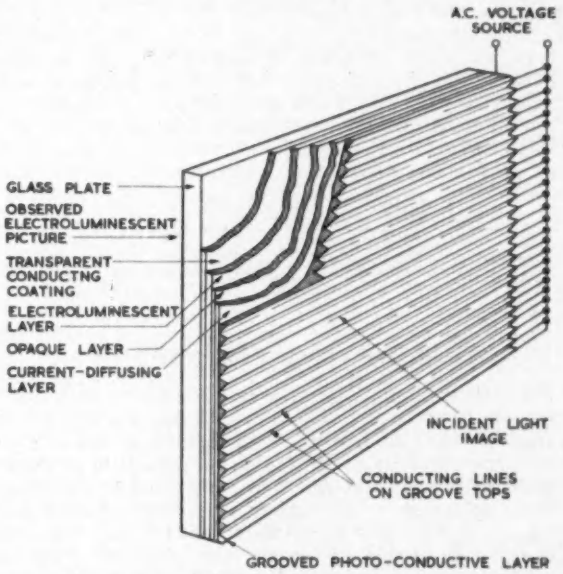


Fig. 30. Grooved photo-conductor type light amplifier (*by Kazan and Nicoll*)

when the photo-conductor is in the dark most of the voltage will be across the phosphor and it will be relatively bright. Thus the range of brightness will be very restricted. Also, since light is being emitted throughout the bulk of the phosphor, there will be an uncontrollable amount of light fed back to the photo-conductor.

To overcome these disadvantages a more complex construction, such as that shown in Fig. 30 is used. A very thin opaque layer covers the phosphor, and on top of this is a low-resistance conducting layer of cadmium sulphide. This is covered by a layer of photo-conducting cadmium sulphide about 0·015in thick which has accurately machined V-shaped grooves cut in it, with a spacing of 40 to the inch. The grooves are cut right to the bottom of the layer and the flat tops, which are about 0·004in wide, carry metal electrodes which are all connected to a common terminal. These modifications result in the photo-conductive layer having a lower capacitance. What is more important is that now the main current flow is down the surfaces of the grooves, and the total resistance is very sensitive to changes in the intensity of the incident radiation. The low-resistance layer of cadmium sulphide acts as a current-diffusing layer, so that the narrow strip at the bottom of a groove can influence a strip of phosphor approximately 0·025in wide. Panel amplifiers of this type have given gains of up to 60, and the resolution

and quality are about equivalent to that of a television picture.

Improvements can be made in several directions For instance, if the opaque layer is omitted, and the current diffusing layer is made thin a fraction of the output light will be fed back to the photo-conductor, and this will lead to a higher overall gain. In addition the sensitivity of the photo-conductor to changes in light intensity, can be increased by using a d.c. biasing current. This increased sensitivity has led to the development of light amplifiers with gains of greater than 100. However it should be pointed out that one of the features inherent in these amplifiers is that with a constant intensity of incident light the gain (and hence the output brightness) continues to increase slowly with time, over a period of many seconds, and even minutes.

Although many uses have been devised for light amplifiers, the most important application has been in connexion with X-rays. In both medical diagnosis and industrial testing it is extremely valuable to be able to see an image directly, as well as to photograph it. The fluoroscope screen which has been used in the past gives a low contrast image of very low intensity—so low that

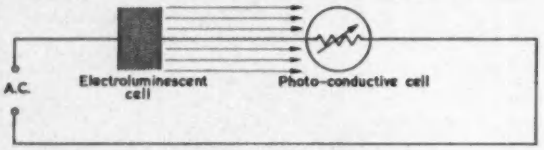


Fig. 31. Photo-conductive-electroluminescent element

observations have to be made in a completely dark room and the observer may have to spend some time in ensuring that his eyes have become adapted to the darkness. With the same intensity of incident X-rays the light amplifier gives an image which is 100 or more times brighter than the fluoroscope. This image is of high contrast and decays slowly over a period of about 30sec with the X-rays off. These advantages mean that the amplifier can give a better image with a lower intensity of irradiation, and that the image can be viewed at close quarters without the necessity for heavy shielding.

X-ray panel amplifiers 12in square have been made with a resolution of 40 lines/in, and more recently, similar panels with 80 lines (grooves) to the inch have been developed. An 800V d.c. bias is used on the photoconductive layer. This besides increasing the gain, is useful in that it enables the observer, by operating a changeover switch which reverses the polarity of the bias, to erase an image at any arbitrary moment during its decay.

Photo-conductive-Electroluminescent Elements

An electroluminescent cell and a photo-conductive cell may be connected in series across a source of alternating voltage, as shown in Fig. 31. If the light emitted by the electroluminescent cell falls on the photo-conductor the combination is effectively a regenerative light amplifier. It is possible so to choose the impedance of the components that a two-state switching device is obtained. In the first stable state the photo-conductor is in the dark and its resistance is so high that very little voltage is available for the electroluminescent cell, which therefore emits no light. An external pulse of light can be used to trigger the circuit into the other stable state. When the photo-conductor is illuminated by this pulse its resistance decreases and the voltage across the electroluminescent cell increases sufficiently for light to be emitted. This causes a further reduction in the resistance of the photo-conductor, which in turn leads to an increase in the brightness of the emission. Once this regenerative action has started it will continue (even though the trigger pulse has been removed), until the second stable state is reached. In this state nearly all the voltage is across the electroluminescent cell, which is emitting at high intensity, and the resistance of the photo-conductor is very low.

It is evident that a circuit of this type can be used as a switch or as a storage element. By using numbers of such elements it is possible to design computer stores, adders, shift registers, flip-flops, counters, etc. They have some attractive features: each element can be made very small, printed circuit techniques can be used in the fabrication, and the suitability for mass production would lead to a low cost per unit. There is however one serious disadvantage—the photo-conductor responds relatively slowly to changes in light intensity. Using cadmium sulphide the switching time for a bistable circuit is at best about 10msec. Thus the operating speed is too slow for these devices to find practical application in digital computers. While they may be useful in special purpose machines where the main requirement is for the handling of a large amount of information at a low cost, the widespread use of photo-conductive-electroluminescent elements must await the development of improved photo-conductor materials.

Conclusion

The aim in the preceding sections has been to give an outline of a representative selection of the many applications which have been found for the phenomena of electroluminescence. Development work in this relatively new field is proceeding in many laboratories and interest continues to increase. It is certain that during the next few years, as techniques are refined and new materials become available, many useful devices will make their appearance.

Acknowledgments

The first part of this article consists mainly of a summary of the results of work done by the author at the Electrical Engineering Laboratories, Manchester University. It is a pleasure to acknowledge the help and advice of a large number of colleagues there.

The information in the second part has been drawn from a number of papers. These are listed in the Bibliography and acknowledgment is made to the authors concerned.

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Design Data for Band-Pass Ladder Filters Employing Ceramic Resonators

By R. C. V. Macario*, B.Sc., Ph.D.

Piezoelectric ceramics which have high electromechanical coupling coefficients and medium Q factors, when in the shape of small circular disks resonating in a radial mode and in conjunction with or without capacitors, make attractive band-pass ladder filters. In the article design feasibility data for a variety of networks are examined and given in the form of graphs with exact design data as tables. These are based on image parameter theory, the justification of which is established by comparing actual filter responses. The ranges of centre frequency, bandwidth and image impedance achievable are discussed.

(Voir page 197 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 204)

A CHAIN of resonant elements can produce a remarkably selective band-pass wave filter with characteristics directly relatable to the individual elements. Using quartz crystal resonators the design of such networks has been well established by W. P. Mason[1] and others[2] using image parameter theory and a simple equivalent circuit for the quartz resonators. The equivalent circuit assumes only reactive components and hence the design equations are very much simplified.

Piezoelectric ceramic resonators on the the other hand must contain a substantial resistive component in their equivalent electric circuit as is evidenced by their much lower Q than quartz crystals[3], but if in the first instance the resistive component is neglected then networks employing ceramic resonators can be designed along the same lines as evolved for quartz crystals. To ascertain the justification of this approach comparison between the measured amplitude/frequency responses of actual filters to those calculated is made, and is also supported by results deduced by recent network theory analysis[4].

The ceramic resonators considered here are in the form of small thin disks and resonate in a radial expander mode. This mode is relatively free from spurious responses and the overtone frequencies are placed the furthest apart[5]. Without the resistive component the equivalent circuit is identical to that of a quartz crystal. In designing a network, the values of the reactances of the equivalent circuit are established from the amplitude response desired for the network, and then the dimensions of the resonators are calculated from a knowledge of the piezoelectric coefficients of the ceramic. Typical values of these coefficients are given in the text. It is noteworthy that piezoelectric ceramics have higher electromechanical coupling coefficients than quartz crystals and consequently they are more attractive for wide bandwidth filters.

Nine ladder section configurations are dealt with, each having ceramic resonators as the primary elements and capacitors as the secondary elements. Design equations, based on image parameter theory, are summarized in the form of graphs and tables. The graphs will be found useful for feasibility design while the tables are used for final values. Filters with disks in both the series and shunt arms are as described by Curran and Geber[6].

A number of actual filter responses[7] indicate that the attenuation curves come reasonably close to the responses expected based on ideal loss-free resonators. Nonetheless, limitations in extreme cases are evident because of the finite Q of the resonators, but the limits on fractional bandwidth for example can be estimated in the manner suggested towards the end of the article.

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General Properties of Piezoelectric Ceramic Disks

Circular disks of ferroelectric ceramic material polarized in thickness vibrate in a radial expander mode when excited by an oscillatory voltage impressed across electrodes silver fired on the two faces[3,5]. In some respects they

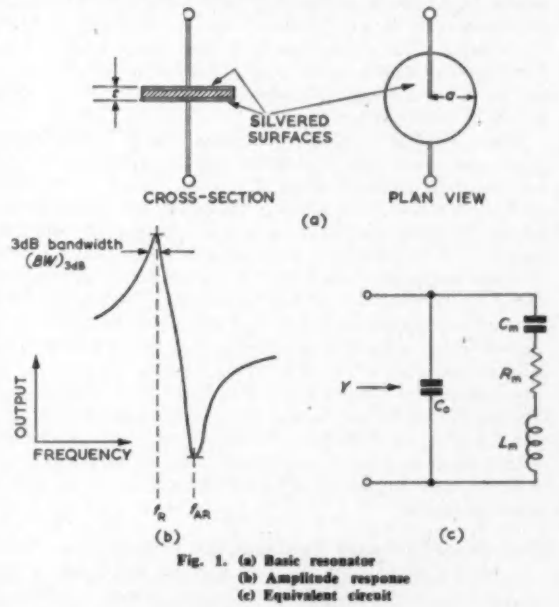


Fig. 1. (a) Basic resonator (b) Amplitude response (c) Equivalent circuit

resemble vibrating plates[8], but due to the boundary condition imposed by the polarization[3] the number of resonances, or tones, are restricted, and this makes them attractive as wave filter elements.

Fig. 1 illustrates the construction of the resonator, the type of frequency response and the equivalent circuit employed. The component values of the equivalent circuit are related to the dimensions of the disk and the piezoelectric properties as follows[9].

The clamped capacitance C_o depends on the relative dielectric constant ϵ of the material, and:

$$C_o = \epsilon_o \epsilon(\pi a^2/t) \quad \ldots\ldots\ldots\ldots \quad (1)$$

where ϵ_o is the permittivity of free space.

a is the radius of the disk.

t is the thickness of the disk.

The mechanical capacitance C_m is proportional to C_o and depends on the electromechanical coupling coefficient k_R of the radial mode. The ratio C_m/C_o also determines

the separation Δf of the resonant f_r and anti-resonant frequency f_{ar}, and the approximate relation between the quantities is:

$$C_m/C_o \simeq (2\Delta f/f_r) = (2/y_o) \cdot \frac{k_R^2}{1 - k_R^2} \quad \ldots\ldots (2)$$

where y_o is a constant depending on the tone considered. For a typical ceramic:

$y_o = 2{\cdot}80$ in the fundamental mode
$= 20{\cdot}6$ in the first overtone mode.

The first overtone is some 2·5 times higher in frequency than the fundamental.

From equations (1) and (2):

$$C_m = K \cdot (a^2/t) \quad \ldots\ldots (3)$$

where K is a constant for a given ceramic and tone, but varies from one material to another. Table 1 gives typical values of Δf and K for different values of coupling coefficient k_R, assuming $\epsilon = 1\,000$. Here $f_r = 470$kc/s. The equivalent inductance L_m is related to C_m by:

$$L_m = 1/4\pi^2 f_r C_m \quad \ldots\ldots (4)$$

while:

$$R_m = 1/2\pi f_r C_m Q_m \quad \ldots\ldots (5)$$

where Q_m is the mechanical Q of the material and is the chief source of loss in the material[9]. For a typical material, C_o is about 150pF in the case of a disk with a fundamental resonance at 470kc/s. C_m is about one-fifth of C_o, while R_m in ohms has approximately the same numerical value as C_m in picofarads.

These relations enable the dimensions of a disk to be calculated from the equivalent circuit established in the course of designing a filter. It is clear, however, that for a filter to be useful in practice the piezoelectric coefficients of the ceramic must be both stable in time and with temperature. A composition promising in this respect is lead titanate zirconate, which has recently been discussed in detail by Berlincourt, Cmolik and Jaffe[9]. This material has a relative dielectric constant of about 1 000, but by including various additives and altering the ratios of the constituent parts k_R may take values ranging from 15 to 50 per cent. Corresponding Q_m values range from 1 000 to 100. The frequency factor F_R (resonant frequency times radius) for the disks is such that practical filters may be realized with a range of centre frequencies from 100kc/s to 1Mc/s. At the higher end of the scale use is made of the first overtone resonance.

Derivation of Design Equations for Ladder Networks

Ladder networks are divisible into discrete sections. The various sections considered contain ceramic resonators and/or capacitors. Each section is assumed to be characterized by an image impedance Z, which may or may not be the same at the opposite terminal pair, and an image transfer constant θ. Thus if the terminal impedances between which the network operates, and the critical frequencies which define the real part (attenuation α) of the image transfer constant are specified, the reactances of the network can be calculated, by prescribing[1,2]

(1) f_1 the lower cut-off frequency,
(2) f_2 the upper cut-off frequency
(3) f_∞ the frequency of infinite attenuation or pole frequency
(4) the image impedance Z at the centre frequency f_c.

The centre frequency is taken as $(f_1 + f_2)/2$.

Relations derived on this basis[1,2,7], form the design equations and are tabulated below for the various sections, divided into groups of three:

(1) Symmetrical single resonator sections.
(2) Unsymmetrical L-sections.
(3) Symmetrical double resonator sections.

Each section is essentially a bridge, T, π, or L-section. Table 2 shows the structure of each basic section alongside the appropriate expression for Z and θ in terms of the branch reactances.

In each network Z_1 refers to the series branch reactance and Z_2 to the shunt branch reactance. A subscript on the image impedance Z, however, is intended to denote the type of section.

Also, if Z_1 is a capacitance say, then:

$$Z_1 = \frac{1}{j2\pi f C_1} \quad \ldots\ldots (6)$$

where C_1 is the value of the capacitor in the series arm. If Z_2 is a piezoelectric resonator, then:

$$Z_2 = \frac{1}{j2\pi f C_{02}} \cdot \frac{f_r^2 - f^2}{f_{ar}^2 - f^2} \quad \ldots\ldots (7)$$

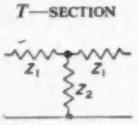
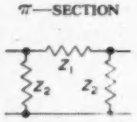
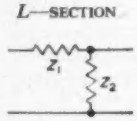
where C_{02} is the electrostatic capacitance, i.e. equation (1). This is related to the equivalent mechanical capacitance:

$$C_2 = \frac{f_{ar}^2 - f_r^2}{f_r^2} \cdot C_{02} \quad \ldots\ldots (8)$$

TABLE 1
Parameters depending on k_R

k_R (per cent)	Δf (kc/s) FUNDAMENTAL	Δf (kc/s) 1st OVERTONE	$K \times 10^{10}$ (pF/m) FUNDAMENTAL
10	1·70	0·39	1·00
15	3·86	0·88	2·28
20	7·00	1·59	4·15
25	11·2	2·55	6·64
30	16·6	3·78	9·82
35	23·2	5·30	13·7
40	32·0	7·30	19·0
45	42·7	9·74	25·3
50	56·0	12·75	33·1

TABLE 2
Image Impedance and Image Transfer Constant for Ladder Sections

SECTION	IMAGE IMPEDANCE Z	IMAGE TRANSFER CONSTANT θ
BRIDGE	$Z_B = \sqrt{(Z_1 Z_2)}$	$2\tanh^{-1}\sqrt{(Z_1/Z_2)}$
T—SECTION 	$Z_T = Z_1\sqrt{(1 + 2Z_2/Z_1)}$	$2\tanh^{-1}\sqrt{\left(\frac{Z_1}{Z_1 + 2Z_2}\right)}$
π—SECTION 	$Z_\pi = Z_2\sqrt{\left(\frac{1}{1 + 2Z_2/Z_1}\right)}$	
L—SECTION 	$Z_T = Z_1\sqrt{(1 + Z_2/Z_1)}$ $Z_\pi = Z_2\sqrt{\left(\frac{1}{1 + Z_2/Z_1}\right)}$	$\tanh^{-1}\sqrt{\left(\frac{Z_1}{Z_1 + Z_2}\right)}$

while the equivalent mechanical inductance is given by equation (4).

Design Equations

In the tables which follow, illustrating three sections apiece, the rows give the following data:

(1) The description of the network.
(2) The structure of the network showing the position of the ceramic resonators and the capacitors.
(3) The shape of the attenuation curve $|\alpha|$ indicating the positions of the critical frequencies.
(4) The value of the frequency parameter m which depends on the choice of shape of the attenuation response.
(5) The value of the capacitor C in terms in the mid-band terminating impedance Z and the frequency factor m.
(6) The value of the resonator electrostatic capacitance C_o in terms of the fixed capacitor.
(7) The value of the resonator mechanical capacitance C_m in terms of the resonator electrostatic capacitance.
(8) The value of the resonator mechanical inductance L_m in terms of the resonator mechanical capacitance.
(9) The identity of the resonator resonant frequency f_r with a critical frequency.
(10) The condition of feasibility, or the maximum separation of the critical frequencies in terms of the resonator frequency difference $\Delta f = f_{ar} - f_r$.
(11) An illustration of the variation of the image impedance over the pass-band, and, in the case of an unsymmetrical L-section, the ratio of the input to output impedances.

The shape of the attenuation and image impedance curves have been derived by the graphical extensions of the equations given in Table 2. In general it is found that for a resonator in the series arm the resonant frequency f_r determines the lower edge of the pass-band while the anti-resonant frequency determines the pole of attenuation in the upper stop band. For a shunt resonator, f_r determines the pole of attenuation in the lower stop-band and f_{ar} the upper edge of the pass-band. A resonator in both arms therefore produces a pole of attenuation in both stop-bands unless the corresponding frequencies overlap cf. column 3, Table 4. Also f_r and f_{ar} do not appear in the design equations since they are identified with one or the other of the critical frequencies f_1, f_2 or f_∞.

Exact expressions for Z and θ for the various sections are given in Table 6. In each case the image impedance is given in terms of the electrostatic capacitance of the series resonator used in the network; the variation of Z with the network response, rather than with the resonator, is then easily assessed.

On the other hand, the image transfer constant is independent of the resonators, and depends only on the critical frequencies of the network response, which are functions of the ratios of the reactances.

Discussion of the Design Equations

ATTENUATION CHARACTERISTIC

An interesting, but restrictive property of ladder sections is their similarity of frequency response, which can be more fully appreciated by the exact computation of $|\theta| \equiv \alpha$ using the equations of Table 6. Three computed patterns are shown in Fig. 2 and refer to a series-L, shunt-L and the double resonator L-section designed to provide the same pass-band and relative attenuation pole. The critical frequencies assumed are:

Centre frequency $f_o = 470$kc/s.
Pass-band width $f_2 - f_1 = 8$kc/s.
Rejection frequency $f_\infty = f_o \pm 10$kc/s.

As expected, the π-section (series resonator) gives a rejection slot in the upper stop-band, the T-section gives a rejection slot in the lower stop-bands, while the double

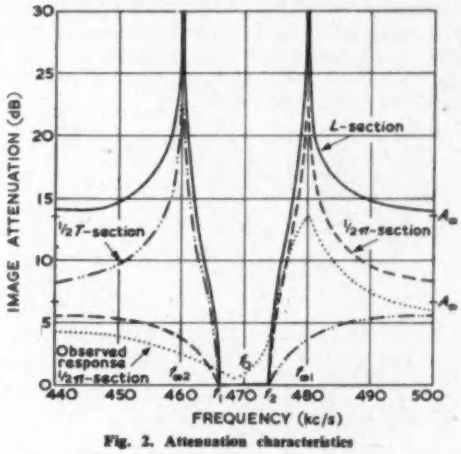


Fig. 2. Attenuation characteristics

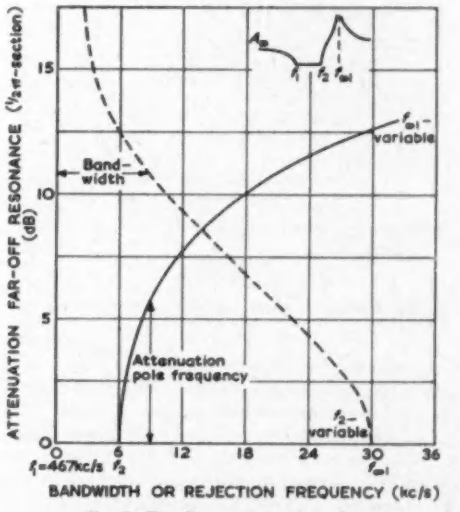


Fig. 3. Far-off resonance attenuation

resonator section gives a rejection slot in both stop-bands.

The attenuation, in decibels is that value which would be observed for resonators having no internal dissipation, that is, infinite Q. The limitations imposed by actual resonators is discussed below, but shown in Fig. 2 is a plot of an observed response for a ½ π-section employing a resonator with a $Q_m = 300$. As expected, a finite Q prevents rapid changes of attenuation slope with frequency with a corresponding loss or introduction of attenuation; but the general pattern is quite evident.

Nonetheless, the attenuation far from resonance does apply and in certain cases is of particular interest, i.e., to suppress overtones. Let the attenuation far from resonance be A_∞. The values of A_∞ for the various sections having the response just described are:

Full section .... A_∞ = 13·6dB
Half section .... A_∞ = 6·8dB

For a long uniform ladder the attenuation far-off resonance is the number of sections times the value for one section.

Now it may arise that the magnitude of A_∞ is more important than the frequency response around resonance i.e., the placing of the attenuation pole. Therefore in Fig. 3 is plotted A_∞ against variation in bandwidth $f_2 - f_1$, centred about 470kc/s, and the positioning of the attenuation pole frequencies f_∞, for a series resonator L-section. The data clearly indicates that A_∞ increases as f_∞ is taken further away from the pass-band, (high K ceramics) or the pass-band is made narrower.

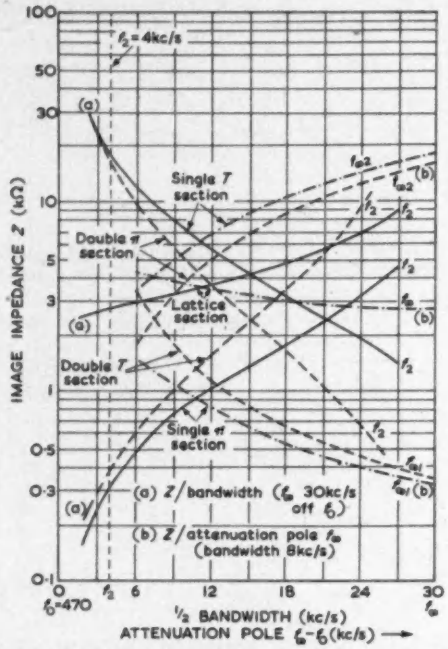


Fig. 4. The variation of image impedance with bandwidth and pole frequency

Image Impedance

A knowledge of the magnitude of the matching impedance in ohms when considering ceramic ladder filters for communication networks, is clearly of importance. Thus in Fig. 4 is shown the variation of Z as a function of the bandwidth and the position of the attenuation pole, for a centre frequency of 470kc/s, assuming the use of ceramic resonators having an electrostatic capacitance $C_o = 150$pF. (This value corresponds to a disk of about 1mm thickness and 4·5mm diameter.)

Scrutiny of the various graphs indicates that π-sections provide low impedance matching, while T-sections provide high impedance matching. Double resonator sections have intermediate Z values. Nonetheless all the curves follow the same general pattern; narrow bandwidths, or pole frequencies far removed from the pass-band, lead to extreme values of Z.

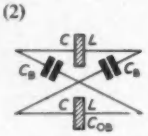
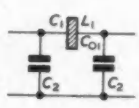
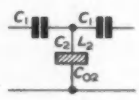
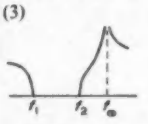
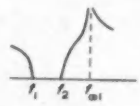
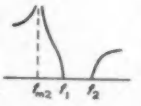
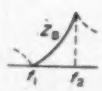
Further, since there is this variation of impedance among sections which have the same frequency response, it is possible to arrange impedance matching. The two methods are (1) combining unsymmetrical networks, and (2) interposing capacitive transformers between sections[7]. This feature is of importance when considering the networks as interstage filters in band-pass amplifiers. Z also varies with centre frequency. As, however, the diameter of the resonator also changes, the complete term involving $\frac{1}{2}\pi f_o C_o$ must be considered and it is easily shown that Z decreases in proportion to f_o. Thus it is conceivable that π-sections could be designed to match 75Ω at a centre frequency of 100kc/s.

Choice of Network

The shape of the attenuation curve and the image impedance variation within the pass-band influence the choice of network for a particular requirement. For instance the 2-disk L-section gives the best response per component[6], but requires the close control of two different disk sizes and has a limited matching impedance range; double T- or π-sections may in fact be more useful in certain cases..

The extent of feasibility is stated briefly in row ten of the design tables. Δf is related to k_R and information about this is given in Table 1. Higher electromechanical coupling coefficients allow a wider variety of networks and matching impedances to be employed, but the ceramic is then usually of low Q-value.

TABLE 3
Symmetrical Single Resonator Sections

(1) BRIDGE	SINGLE—π	SINGLE—T
(2) 		
(3) 		
(4) $m^2 = \dfrac{f_\infty^2 - f_1^2}{f_\infty^2 - f_2^2}$	$m_1^2 = \dfrac{f_{\infty 1}^2 - f_1^2}{f_{\infty 1}^2 - f_2^2}$	$m_2^2 = \dfrac{f_{\infty 2}^2 - f_1^2}{f_{\infty 2}^2 - f_2^2}$
(5) $C_B = \dfrac{1}{2\pi f_2 m Z_B}$	$C_2 = \dfrac{1}{2\pi f_2 m_1 Z_\pi}$	$C_1 = \dfrac{1}{2\pi f_2 m_2 Z_T}$
(6) $C_{OB} = m^2 C_B$	$C_{01} = \dfrac{m_1^2 - 1}{2} C_2$	$C_{02} = \dfrac{2m_2^2}{1 - m_2^2} C_1$
(7) $C = \dfrac{f_2^2 - f_1^2}{f_1^2} C_{OB}$	$C_1 = \dfrac{f_{\infty 1}^2 - f_1^2}{f_1^2} C_{01}$	$C_2 = \dfrac{f_2^2 - f_{\infty 2}^2}{f_{\infty 2}^2} C_{02}$
(8) $L = \dfrac{1}{4\pi^2 f_1^2 C}$	$L_1 = \dfrac{1}{4\pi^2 f_1^2 C_1}$	$L_2 = \dfrac{1}{4\pi^2 f_{\infty 2}^2 C_2}$
(9) $f_r = f_1$	$f_r = f_1$	$f_r = f_{\infty 2}$
(10) $\Delta f \geq f_2 - f_1$	$\Delta f \geq f_{\infty 1} - f_1$	$\Delta f \geq f_2 - f_{\infty 2}$
(11) 		

Utilization of Equations

For a given choice of networks, the appropriate design relations are found in Tables 3 to 5 and enable the equivalent circuit elements to be calculated.

The dimensions of the resonators are evaluated using previous relations, namely:

$$\text{radius} \quad a = F_R/f_r \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

$$\text{thickness} \quad t = Ka^2/C_m \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

The electrostatic capacitance C_o follows from equation (1).

When the ceramic used lies within the condition of feasibility of the network, it will be found that:

$C_o < C_{o_\pi}$ etc.

Thus an additional external capacitor must be added across the disk, of value:

$$C_e = C_{o_\pi} - C_o \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

Numerical Example

Suppose that a double-T section is required to work between impedances of 1kΩ and provide a bandwidth of 8kc/s at 470kc/s with the rejection slot placed 10kc/s above the centre of the pass-band.

$f_o = 470\text{kc/s}$ $\quad f_{\infty 1} = 480\text{kc/s}$

$f_1 = 466\text{kc/s}$ $\quad Z = 1\text{k}\Omega$

$f_2 = 474\text{kc/s}$

Using the equations of column 2 of Table 5:

$m_1^2 = 1{\cdot}315$ $\quad C_{01} = 224\text{pF}$

$C_2 = 340\text{pF}$ $\quad C_1 = 13{\cdot}6\text{pF}$

and $f_r = f_1 = 466\text{kc/s}$.

The feasibility condition is $\Delta f > f_{\infty 1} - f_1 = 14\text{kc/s}$. From Table 1 this specifies the use of a ceramic with a coupling coefficient $k_R > 30$ per cent.

TABLE 4
Unsymmetrical L-Sections

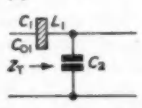
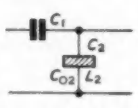
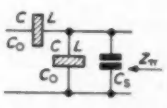
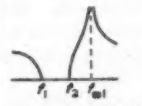
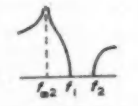
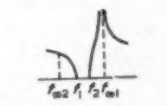
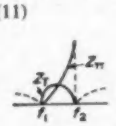
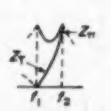
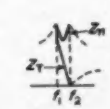
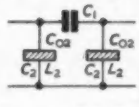
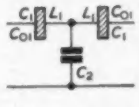
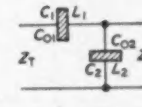
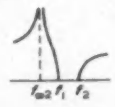
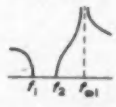
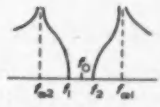
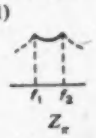
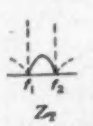
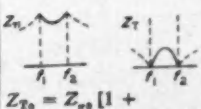
(1) SERIES—L	SHUNT—L	SERIES SHUNT—L
(2) 		
(3) 		
(4) $m_1^2 = \dfrac{f_{\infty 1}^2 - f_r^2}{f_{\infty 1}^2 - f_1^2}$	$m_2^2 = \dfrac{f_2^2 - f_{\infty 2}^2}{f_1^2 - f_{\infty 2}^2}$	$m^2 = \dfrac{f_\infty^2 - f_1^2}{f_{\infty 1}^2 - f_2^2}$
(5) $C_2 = \dfrac{m_1}{2\pi f_o Z_\pi}$	$C_1 = \dfrac{m_2}{2\pi f_o Z_T}$	$C_o = \dfrac{(1+m^2)}{2\pi f_o Z_{To}}$
(6) $C_{01} = \dfrac{1 - m_1^2}{m_1^2} C_2$	$C_{02} = \dfrac{1}{m_2^2 - 1} C_1$	$C_s = \dfrac{1 - m^2}{m^2} C_o$
(7) $C_1 = \dfrac{f_{\infty 1}^2 - f_1^2}{f_1^2} C_{01}$	$C_2 = \dfrac{f_2^2 - f_{\infty 2}^2}{f_{\infty 2}^2} C_{02}$	$C = \dfrac{f_{\infty 1}^2 - f_{\infty 2}^2}{f_{\infty 2}^2} C_o$
(8) $L_1 = \dfrac{1}{4\pi^2 f_1^2 C_1}$	$L_2 = \dfrac{1}{4\pi^2 f_{\infty 2}^2 C_2}$	$L = \dfrac{1}{4\pi^2 f_{\infty 2}^2 C}$
(9) $f_r = f_1$	$f_r = f_{\infty 2}$	$f_r = f_{\infty}$
(10) $\Delta f \geq f_{\infty 1} - f_1$	$\Delta f \geq f_2 - f_{\infty 2}$	$\Delta f \geq f_{\infty 1} - f_{\infty 2}$
(11) 		
$Z_{\pi 0} = (1 + m_1^2) Z_{To}$	$Z_{\pi 0} = \dfrac{1 + m_2}{m_2} Z_{To}$	$Z_{\pi 0} = 2(1 + m^2) Z_{To}$

TABLE 5
Symmetrical Double Resonator Sections

(1) DOUBLE—π	DOUBLE—T	SYMMETRICAL DOUBLE—L
(2) 		
(3) 		
(4) $m_2^2 = \dfrac{f_2^2 - f_1^2}{f_1^2 - f_{\infty 2}^2}$	$m_1^2 = \dfrac{f_2^2 - f_1^2}{f_{\infty 1}^2 - f_2^2}$	$m_1^2 = \dfrac{f_{\infty 1}^2 - f_2^2}{f_{\infty 1}^2 - f_1^2}$ $m_2^2 = \dfrac{f_2^2 - f_{\infty 2}^2}{f_1^2 - f_{\infty 2}^2}$
(5) $C_1 = \dfrac{1}{2\pi f_o Z_\pi}$	$C_2 = \dfrac{1}{2\pi f_o Z_T}$	$C = \dfrac{1}{2\pi f_o \sqrt{(Z_\pi Z_T)}} \left[\dfrac{1 + m_2^2}{1 + m_1^2}\right]^{\frac{1}{2}}$
(6) $C_{02} = \dfrac{2}{m_2^2} C_1$	$C_{01} = \dfrac{m_1^2}{2} C_2$	$C_{01} = \dfrac{1 - m_1^2}{2} C$ $C_{02} = \dfrac{2}{m_2^2 - 1} C$
(7) $C_2 = \dfrac{f_2^2 - f_{\infty 2}^2}{f_{\infty 2}^2} C_{02}$	$C_1 = \dfrac{f_{\infty 1}^2 - f_1^2}{f_1^2} C_{01}$	$C_1 = \dfrac{f_{\infty 1} - f_o^2}{f_o^2} C_{01}$ $C_2 = \dfrac{f_o^2 - f_{\infty 2}^2}{f_{\infty 2}^2} C_{02}$
(8) $L_2 = \dfrac{1}{4\pi^2 f_{\infty 2}^2 C_2}$	$L_1 = \dfrac{1}{4\pi^2 f_1^2 C_1}$	$L_1 = \dfrac{1}{4\pi^2 f_o^2 C_1}$ $L_2 = \dfrac{1}{4\pi^2 f_{\infty 2}^2 C_2}$
(9) $f_r = f_{\infty 2}$	$f_r = f_1$	$f_{r1} = f_o \quad f_{r2} = f_{\infty 2}$
(10) $\Delta f \geq f_2 - f_{\infty 1}$	$\Delta f \geq f_{\infty 1} - f_1$	$\Delta f_1 \geq f_{\infty 1} - f_o$ $\Delta f_2 \geq f_o - f_{\infty 2}$
(11)  Z_π	 Z_T	 $Z_{To} = Z_{\pi 0}[1 + (C_{02}/C_{01})] m_1^2 m_2^2$

Suppose that the following ceramic is available:

$k_R = 40$ per cent $\quad \epsilon = 1250$

Radial frequency factor $F_r = 110$kc/s. Thus:

$$a = F_R/f_r = 0{\cdot}236\text{cm}$$

Since $t = K \cdot a^2/C_1$, and taking K from Table 1, and the new dielectric constant into account:

$$\therefore\ t = 1{\cdot}25K_\epsilon \cdot (a^2/C_1) = 0{\cdot}971\text{mm}$$

$$\therefore\ C_0 = \epsilon_0 \cdot \epsilon \cdot (\pi a^2/t) = 183\text{pF}$$

Thus the disk must be padded with an additional capacitance:

$$C_e = C_{01} - C_0 = 41\text{pF}.$$

Hence two disks are required of 4·72mm diameter, 0·971mm thickness, both padded with 41pF and a shunt capacitance $C_2 = 340$pF.

The attenuation far-off resonance will be 13·2dB.

The shape of the (ideal) attenuation curve will be as shown in Fig. 2 for the $\frac{1}{2}\pi$-section, but with twice the value of attenuation.

If a rejection slot in the lower stop-band is also required a π-section must be added in series with the above section.

With the previous parameters, except now $f_{\infty 2} = 460$kc/s, then in the same manner it is found that:

$$a = 0{\cdot}239\text{cm} \qquad C_1 = 340\text{pF}$$

$$t = 0{\cdot}432\text{cm} \qquad C_0 = 87\text{pF}$$

Hence a much thinner disk is specified if the same matching impedance is to be met. In some cases the thickness of the disk will be outside the range of practical thickness to diameter ratios (about 1:5) or too fragile (less than 0·5mm thick). Fig. 4 is designed to illustrate the range of matching impedance that is available when using disks of average thickness.

Design Limitation on Practical Filters

Impedance Mismatch

The data given aims at matching the image impedance at centre frequency, but it is fairly clear that considerable mismatch must occur at the edges of the pass-band for terminal sections, but it need not be serious[10]. Even so, for long ladders the effect is small and resonator dissipation is the more serious limitation.

Finite Resonator Q

The effect of using disks with a finite Q rather than ideal loss-free resonators is to introduce insertion loss in the pass-band and to prevent rapid changes in the attenuation versus frequency slope, as is evident in Fig. 2. The latter effect limits the minimum practical bandwidth, but it need not limit the shape factor, provided the pass-band is not too narrow, and very good shape factors can be achieved with long ladders.

Fig. 5 illustrates, with the aid of the response of two actual filters[7], the improvement of shape factor as sections (disks) are added and also how too narrow a bandwidth design deteriorates the actual filter response. The response aimed at is shown dotted in the diagram. Similar effects are noticeable for the data illustrated by Curran and Geber[6] pertaining to much longer filters. All, however, are based on image parameter design theory, and only when a very narrow bandwidth is aimed at, does insertion loss and departure from an ideal response become serious. Estimation of this limit can thus be regarded as an additional condition of feasibility and provided all the desired filter specifications fall within the conditions outlined, the design will be met.

Exact network theory[11] deals specifically with elements of a finite Q and the results may be applied here.

For instance a specific performance can be met with any

TABLE 6

Image Constants in Terms of the Critical Frequencies

SECTION	IMAGE IMPEDANCE Z	IMAGE TRANSFER CONSTANT θ
Bridge	$\dfrac{1}{2\pi f_0 C_0}\left[\dfrac{f_\infty^2 - f_1^2}{f_\infty^2 - f_2^2}\right]^{\frac{1}{2}}$	$2\tanh^{-1}\left[\dfrac{f_\infty^2-f_2^2}{f_\infty^2-f_1^2}\dfrac{f_1^2-f^2}{f_2^2-f^2}\right]^{\frac{1}{2}}$
Single π	$\frac{1}{2}\dfrac{1}{2\pi f_0 C_{01}}\dfrac{f_2^2-f_1^2}{\sqrt{[(f_{\infty 1}^2-f_1^2)(f_{\infty 1}^2-f_2^2)]}}$	$2\tanh^{-1}\left[\dfrac{f_{\infty 1}^2-f_2^2}{f_{\infty 1}^2-f_1^2}\dfrac{f_1^2-f^2}{f_2^2-f^2}\right]^{\frac{1}{2}}$
Single T	$2\dfrac{1}{2\pi f_0 C_{02}}\dfrac{\sqrt{[(f_2^2-f_{\infty 2}^2)(f_1^2-f_{\infty 2}^2)]}}{f_2^2-f_1^2}$	$2\tanh^{-1}\left[\dfrac{f_1^2-f_{\infty 2}^2}{f_2^2-f_{\infty 2}^2}\dfrac{f_2^2-f^2}{f_1^2-f^2}\right]^{\frac{1}{2}}$
Series L	$Z_{\pi 1} = 2Z_\pi$	$\frac{1}{2}$ (Single π)
Shunt L	$Z_{T_2} = \dfrac{Z_T}{2}$	$\frac{1}{2}$ (Single T)
Series Shunt L	$Z_T = \dfrac{1}{2\pi f_0 C_{01}}\dfrac{f_0^2-f_{\infty 2}^2}{f_{\infty 1}^2-f_0^2}\left[\dfrac{f_{\infty 1}^2-f_1^2}{f_{\infty 1}^2-f_2^2}\right]^{\frac{1}{2}}$	$\tanh^{-1}\left[\dfrac{f_{\infty 1}^2-f_2^2}{f_{\infty 1}^2-f_1^2}\dfrac{f_1^2-f^2}{f_2^2-f^2}\right]^{\frac{1}{2}}$
Double π	$2\dfrac{1}{2\pi f_0 C_{02}}\dfrac{f_1^2-f_{\infty 2}^2}{f_2^2-f_1^2}$	$2\tanh^{-1}\left[1+\dfrac{f_2^2-f_1^2}{f_1^2-f_{\infty 2}^2}\dfrac{f_{\infty 2}^2-f^2}{f_2^2-f^2}\right]^{-\frac{1}{2}}$
Double T	$\frac{1}{2}\dfrac{1}{2\pi f_0 C_{01}}\dfrac{f_2^2-f_1^2}{f_{\infty 1}^2-f_2^2}$	$2\tanh^{-1}\left[1+\dfrac{f_2^2-f_1^2}{f_{\infty 1}^2-f_2^2}\dfrac{f_{\infty 1}^2-f^2}{f_1^2-f^2}\right]^{-\frac{1}{2}}$
Double L	$Z_T = \dfrac{1}{4\pi f_0 C_{01}}\left[1-\dfrac{(f_2^2-f_1^2)^2}{4(f_{\infty 1}^2-f_1^2)(f_{\infty 2}^2-f_1^2)}\right]^{\frac{1}{2}}\dfrac{f_2^2-f_1^2}{f_{\infty 1}^2-f_0^2}$	$\tanh^{-1}\left[1-\dfrac{(f_2^2-f_1^2)^2}{4(f_{\infty 1}^2-f_1^2)(f_{\infty 2}^2-f_1^2)}\right]^{-\frac{1}{2}}\dfrac{f_0^2-f^2}{\sqrt{[(f_1^2-f^2)(f_2^2-f^2)]}}$

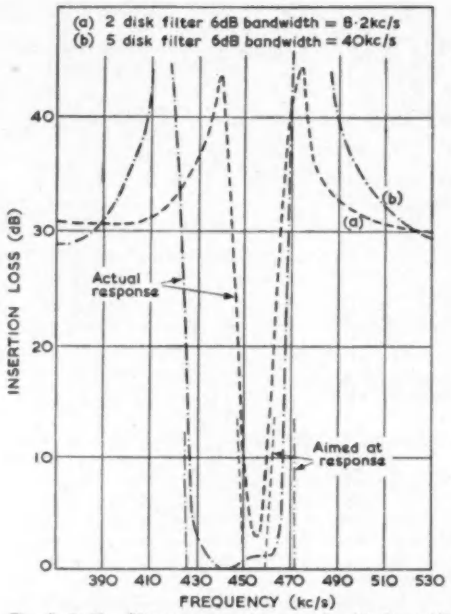


Fig. 5. Ladder filter response using ceramic with Q = 400

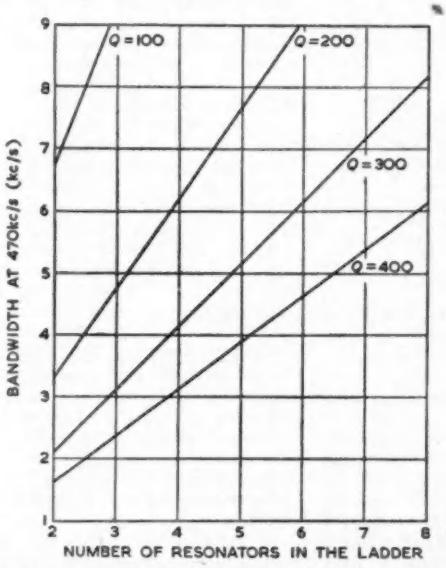


Fig. 6. Minimum bandwidth versus number of resonators in the ladder

network provided that the reactive elements have:

$$Q > \frac{q_{min}}{\text{fractional bandwidth}} \quad \ldots\ldots\ldots (12)$$

where q_{min} is a dissipation factor, and as usual, fractional bandwidth is the ratio of the 3dB bandwidth to the centre frequency. For a band-pass network q_{min} increases as the number of resonators N in the network increases, and data about this is readily available[4].

Alternatively one may write the condition as:

$$(bw)_{3dB} \geq \frac{q_{min} \cdot f_o}{Q} \quad \ldots\ldots\ldots\ldots (13)$$

Taking the centre frequency as 470kc/s, Fig. 6, illustrates the necessary increase in minimum bandwidth as the number of resonators employed increases. The values of Q_m are those most likely to be encountered with piezoelectric ceramics.

The data is readily extended to larger values of N, and suggests the minimum bandwidth possible using N disks at 470kc/s. Examination of actual filter data[6,7] supports these conclusions. It is noted that data on shape factor versus number of resonators is similarly available[4].

As the minimum bandwidth is approached mid-band insertion loss increases. An approximate expression for the

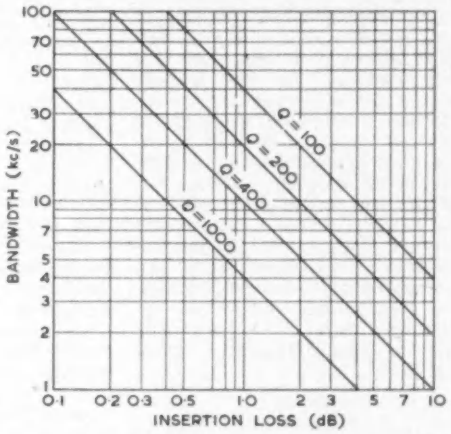


Fig. 7. Image insertion loss per section at centre frequency of 470kc/s

mid-band image insertion loss is:

$$\frac{9 \cdot f_o}{(bw)_{3dB} \cdot Q_m} \text{ dB per section.}$$

This loss is plotted in Fig. 7, again for specific values of Q_m, versus bandwidth for a centre frequency of 470kc/s, and shows that narrow bandwidth filters are clearly prohibited unless high Q ceramics become available.

Conclusions

Piezoelectric ceramics in the form of disks are simple and compact resonators with an electrical behaviour well understood in terms of the material properties. They may well replace coils in medium grade filters. A summary of the design relations for such filters has been attempted here.

Acknowledgments

The author would like to acknowledge the encouragement and advice of Mr. W. Renwick in this work, and is also indebted to the Directors of the Plessey Company Ltd for permission to publish this article.

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LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

Introduction to the Ternary Code Number System

DEAR SIR,—With reference to the article by Mr. Morris and Dr. Alexander on the ternary number system (September 1960) and the subsequent correspondence (December 1960), the basis of the economy argument for the ternary system may be summarized as follows.

If R valves (or other major components) are used in a ring having R stable states as a stage in a scaler, each stage added increases the logarithm of the overall count by $\log R$ and the total number of valves by R. It follows that the value of R which gives the greatest overall count for a given number of valves is the value which makes $\log R/R$ greatest. The logarithm may be taken to base e or to base 10, as preferred. Referring to a set of logarithm tables to base 10,

$$\frac{\log 2}{2} = \frac{0{\cdot}3010}{2} = 0{\cdot}1505$$

$$\frac{\log e}{e} = \frac{0{\cdot}4343}{2{\cdot}7183} = 0{\cdot}1598$$

$$\frac{\log 3}{3} = \frac{0{\cdot}4771}{3} = 0{\cdot}1590$$

$$\frac{\log 4}{4} = \frac{0{\cdot}6020}{4} = 0{\cdot}1505$$

$$\frac{\log 5}{5} = \frac{0.6990}{5} = 0{\cdot}1398$$

The maximum ratio is to be found at e, as may be deduced by differentiating the function $\log x/x$, and the integer giving the maximum ratio is 3. However, it is immediately apparent from an examination of the actual ratios given on the right that there is little to choose between the first three values of R given, in this respect, as the maximum is a broad one and the changes in the ratio are small. It has been appreciated from the earliest days of electronic counting[1] that the binary system has inherent advantages of simplicity, stability and freedom from critical components or adjustments. It is likely in most cases that a tristable circuit could only be obtained with a greater number of auxiliary components per valve than a bistable circuit. This would probably more than offset the narrow margin of economy in the number of valves. Finally, the binary system is ideally suited to many means of recording, such as punched paper tape and cards. In magnetic recording, it has the advantage that the recording of a 0 or a 1 can be distinguished from no signal or a failure to record. It would seem, therefore, that the present extensive use of the binary system (as the main alternative to recording with decimal devices such as Dekatrons) is well founded and that there is no good case for the use of ternary numbers.

Yours faithfully,

C. H. VINCENT,

U.K.A.E.A., Aldermaston.

REFERENCE

1. WYNN-WILLIAMS, C. E. A Thyratron "Scale-of-Two" Automatic Counter. *Proc.Roy.Soc. 136*, 312, (1932).

The Authors' reply:

DEAR SIR,—We would like to thank Dr. Vincent for his most interesting letter and for all his comments which we fully agree with. However, there are some points which we would like to bring up.

The economy of equipment is gained by the choice of a given radix but also depends greatly on the type of component which is going to be used. From a purely theoretical viewpoint, the most efficient utilization of equipment is that using base 3.

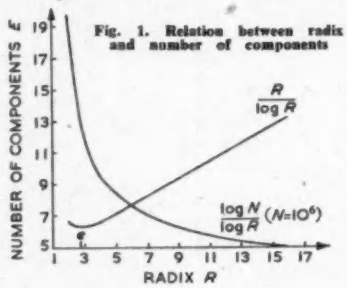

Fig. 1. Relation between radix and number of components

The number of components E is a function of $R \log N/\log R$, thus as N is a constant the ratio leaves $R/\log R$. The minimum ratio will be found at e and the nearest whole number is 3. As shown by Dr. Vincent, there is very little to choose between radix 3 and the radix 2 or 4, and thus the choice of radix as the practical basis for computers is fully justified. However, we feel that the theoretical advantages of radix 3 may have some future practical applications and a computer has already been built in Russia which utilizes this base. This computer, SETUN[1], was constructed at Moscow State University for experimental purposes and was built in some respects 'as a protest against the huge and complicated machines being built elsewhere'.

As shown in our previous letter (December 1960) there are some components which have the number of stable states identical to the radix, thus the number of components E' will now be proportional to n giving $E' = \log N/\log R$. N is a fixed value representing the largest number which can be accommodated by this system.

The following tables and curves of Fig. 1. show the relationship between the radix and the amount of equipment for both types of components ($E = R \log N/\log R$ and $E' = \log N/\log R$) taking N as fixed 10^6 and referring to a set of logarithm tables, to base 10.

R	$\frac{R}{\log R}$	$R\frac{\log N}{\log R}$	$\frac{\log N}{\log R}$
2	6·64	39·84	19·92
e	6·25	37·50	13·81
3	6·29	37·74	12·58
4	6·64	39·84	9·46
5	7·15	42·90	8·58
8	8·86	52·84	6·61
10	10·00	60·00	6·00
12	11·12	66·72	5·56
16	13·29	79·74	4·98

In practice both types of components are used in one machine, for example most computers have magnetic cores as storage elements and valves or transistors as logical elements. It can be seen from both curves that radix 3 is far more efficient than radix 2. However, in practice other things have to be taken into account before choosing the radix for a specific machine, one of the main considerations being the switching speed of the component and another the stability of each state. If, however, a three state device is to be found which can switch at the same switching rate as the two state device then it will have far greater advantage. When the article was written this problem was considered from a purely theoretical aspect, however, a three state device has been developed recently and was published at the same time as our article. This component is a magnetic film[2] which has three stable states and can be used for storage and logical ternary applications at fast switching speeds. Other types of ternary circuits have also been developed[3–6] but are at the present of little practical use.

The computer binary stores which are designed today[7] using two cores per bit can easily be extended to ternary stores without changing any of the driving circuits or any reduction in the cycle time. This gives the possibility of storing more information with the same number of cores.

In future developments the information from one computer may be required to be transmitted to another computer miles away. This is already done for military purposes but will also have some applications for transmitting bank accounts or in other similar fields. The time it takes for the transmission of such information is most important and ternary codes can speed the transmission compared with binary codes.

Coming back to Dr. Vincent's letter, we fully agree with him that the binary system is ideal for special types of recording. The use of ternary codes may only complicate the machine if the information is stored on punched paper tape or cards but only the future will show if ternary arithmetic can be applied in practice. We feel that for some applica-

tions ternary arithmetic will have the advantage over binary.

The article by C. E. Wynn-Williams which was mentioned in Dr. Vincent's letter is most interesting and shows the advantages of binary in an extremely attractive light, but there is no comparison of the binary system with other systems and there is no mention of the ternary system.

Yours faithfully,

D. J. MORRIS AND W. ALEXANDER,
University of Nottingham.

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Fast Counting Circuits

DEAR SIR,—The article by Mr. J. A. Goss in your October 1960 issue is very interesting. His counter works on similar principles to one which has been designed at the National Engineering Laboratory this year. Our counter operates by noting the condition (1 or 0) of each of the four binary stages which form a decade and using this information to determine which stages will be switched by the next pulse in. When this pulse arrives it is directed, via gates, to the stages requiring switching, and simultaneously to the next decade if a carry is involved.

By using this technique we propagate a count through the twenty binary stages that form a 5-decade counter in 2μsec although the individual binary stages on which the work was carried out have each a 2μsec delay and 10μsec resolution time. A normal counter would require 40μsec to propagate the count. Because the binary stages are switched in parallel rather than in series, and because the output pulse may have passed through up to five gates in series, the pulse shape is reformed by using transistors rather than diodes in each gate and this causes the total delay of 2μsec due to the OC140 transistors which it was convenient to employ.

The counter we have designed is in some ways more convenient than that described by Mr. Goss:-

(a) It employs four identical binary stages to each decade.
(b) It employs normal binary codes for the decimal numbers, enabling analogue read-out.
(c) It can be used to add or subtract two pulse trains even when pulses at both inputs overlap or coincide.
(d) The control of the binary stages to obtain a decimal count is simple.

The complete counter is described in a forthcoming paper but a brief description will indicate the method employed. Fig. 1 shows a complete decade. By making binary 3 (0011) the decimal zero, binary 12 (1100) becomes decimal 9. The next input pulse makes the count 1101, but also finds the AND gate opened by the d.c. voltages from the two most significant binary stages *c* and *d*. The pulse through the gate proceeds to reverse stages *b*, *c* and *d* so that the final condition is 0011 in stages *d*, *c*, *b* and *a* respectively which is the required decimal zero. Note that all four stages have been switched simultaneously by the applied pulse. The pulse also proceeds simultaneously to the following decade.

When used in a subtracting sense the change from 0011 to 1100 is carried out in the same simple manner.

Fig. 2 shows one complete binary stage—each one is identical. The d.c. output from a binary unit is delayed by R_1C_1 until the pulse has either been passed on, or blocked, at the subsequent gate, due to the d.c. output which was supplied to it before the pulse arrived. C_1R_1 serves also as a differentiating circuit to sharpen the carry pulse. The values shown were chosen to suit a commercial 100kc/s binary unit available in a potted block form. Higher frequency values could be used for faster binaries. If economy is important only one pulse-shaping gate is essential in each decade. Diode gates could be used for the other three binary stages but we have chosen to make each stage a similar plug-in-unit.

Using these 100kc/s binaries add/subtract counters have been constructed which can deal with two separate input pulse trains each up to 30kc/s with no restriction on phase relation and which provide perfect adding or subtracting. An additional input stage intercepts pulses on the two lines when they are closer than 12μsec and produces two new pulses 20μsec apart which can be added into the counter or ignored when subtracting.

Counters which can reliably indicate a running difference between two pulse trains can be applied to the precision control of shaft speed[1], to analogue/digital convertors, digital differential analysers, the locking of two shafts to any desired speed ratio, and to the correction in error of worm-wheel tooth pitch error or rack and pinion pitch error. They have many applications in laboratory measurement, for example, a crystal oscillator frequency can be subtracted (or added) to a frequency being observed without any filtering, and is thus capable of performing over very wide bands without tuning. Alternatively, the difference between nominally equal frequencies can be indicated, or used for phase-locking purposes. A stroboscope can be arranged to trigger at the difference (or sum) of a frequency derived from shaft rotation and a much lower frequency which will determine the apparent rotational velocity of the shaft when illuminated by the stroboscope. This apparent velocity is not affected by shaft speed over a wide range.

Yours faithfully,

W. H. P. LESLIE AND D. NAIRN,
National Engineering Laboratory,
Glasgow.

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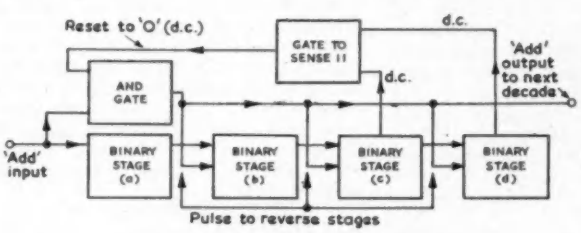


Fig. 1. Arrangement of complete decade

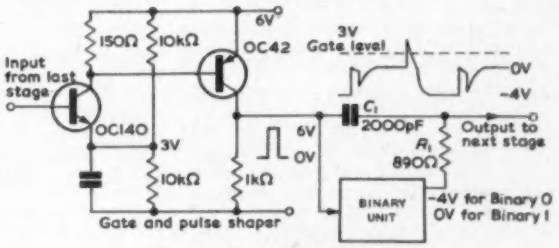


Fig. 2. A complete binary stage

The Author replies:

DEAR SIR,—Mr. Leslie's system achieves a fast carry propagation with relatively slow speed binaries; however, the maximum input frequency is still limited by the successive carries through individual binaries and propagation through the gates which occur at the critical transition between counts of 1101 and 1100. The object of 'Isabel' is to exploit the capabilities of flip-flops to the full in a decade counter while keeping the cost comparable with a straightforward scale of 16 counter, and also to obtain comparatively fast carry propagation. If the fastest possible carry is necessary, there is no reason why the principle of generating the carry from the gated input signal should not be used with 'Isabel'.

The reversible version of 'Isabel' will, of course, also cope with simultaneous 'add' and 'subtract' input pulses when preceded by units for storing and commutating the input signals.

Yours faithfully,

J. A. Goss,
Racal Engineering Ltd,
Berkshire.

BOOK REVIEWS

High Frequency Applications of Ferrites

By J. Roberts. 166 pp. 46 figs. Crown 8vo. English Universities Press Ltd. 1960. Price 16s.

THIS book is written for final year students of physics and electrical engineering, postgraduate students, and research workers. It should also have a wide appeal among all those working on the application of magnetic materials, both metallic and ceramic; the author takes every opportunity of comparing the high frequency applications of the two types.

The author commences with a general introduction to the structural magnetic, and electrical properties of the ferrite magnetic materials and then proceeds to allot one chapter to each of the four main fields of high frequency application. The first of these chapters is devoted to the use of ferrite cores for inductors and transformers. Then follows a very thorough section on the microwave applications of ferrites which is particularly valuable for its simple theoretical treatment of this complex subject. The third chapter deals with computer applications with sections on magnetic shift registers and ferrite core memory stores. The book concludes with a section on permanent magnet materials which pays particular attention to the factors governing the choice between metallic and ferrite magnetics. This chapter also contains a few pages on the allied Ferroxplana materials which are used in inductors and transformers at very high frequencies.

This book is to be thoroughly recommended not only because of its complete coverage of the subject and easily read style but also because it appears to be the only book on the application of ferrites at high frequencies.

A. W. SIMPSON

Reports on Progress in Physics—Volume XXIII

Edited by A. C. Stickland. 629 pp. 268 figs. Crown 4to. The Physical Society. London. 1960. Price 63s.

OF the ten papers in this new volume from The Physical Society, only two can be said to be of immediate interest to the electronic engineer. The first of these has the title *Group Theory in Solid State Physics* and is by D. F. Johnston of the Atomic Energy Research Establishment. The paper is presented in two parts and is addressed to both the postgraduate student approaching the subject for the first time and the reader already acquainted with the principles of group theory. The first part is concerned with the abstract aspects of group theory. The concept of a vector space irreducible under a set of operators is introduced and then related to the many-particle formalism of quantum theory. This is followed by a development of the calculus of the irreducible matrix representations of finite groups. In the second part, the theory of groups is applied to solid state problems. The topics selected for discussion are: the symmetry group of the Dirac Hamiltonian, Wigner time-reversal symmetry, group theory and the many-electron problem, and the irrreducible representations of space-groups.

The second paper of direct interest to the electronic engineer is by H. J. J. Braddick of the University of Manchester and has the title *Photoelectric Photometry*. This paper is concerned with the theory and practice of photoemissive cells and other photometric devices. Some of the known ultra-violet detectors and the use of the internal photoelectric effect in semiconductors for infra-red detection are described. Certain scientific and industrial uses of photoelectric photometry are explained and these include weak light photometry for astronomical purposes, multi-channel spectroscopy for industrial analysis, and some differential applications such as the investigation of the local magnetic fields over the sun's disk using the Zeeman effect of selected spectral lines.

The remainder of the volume contains little that would be of interest to electronic engineers other than those working in highly specialized fields.

S. R. DEARDS

Basic Ultrasonics

By C. Glickstein. 137 pp. 120 figs. Medium 8vo. Chapman and Hall Ltd. 1960. Price 32s.

THIS book is intended as an introduction to ultrasonics. The first section of the book includes a discussion of the general theory of ultrasonics with special reference to the nature of sound and ultrasound waves. The second section covers the basic types of ultrasonic equipment. For this section an elementary knowledge of electronics on the part of the reader is assumed. The third part describes in detail the most important ultrasonic applications.

Mechanical Waveguides

By Martin R. Redwood. 300 pp. 93 figs. Demy 8vo. Pergamon Press Ltd. 1960. Price 50s.

THE subject matter of this book is indicated by the sub-title: "The propagation of acoustic and ultrasonic waves in fluids and solids with boundaries." Interest in this subject stems from its relevance to the study of the properties of materials and to such diverse fields as the properties of ultrasonic delay lines and seismology. The object of the book is to give a comprehensive account of the basic properties of guided waves in solids and fluids: an introductory chapter on stress-strain relationships is followed by detailed analyses of the types of wave which can arise in a variety of different conditions. This material is clearly presented and although essentially theoretical in character it is related to the available experimental evidence where appropriate. The bulk of the treatment refers to steady state propagation in isotropic materials. Later chapters consider the complications which arise when transients and non-isotropic media have to be considered.

The title of the book invites comparison with electromagnetic waveguides and it is a little surprising to find that this is not discussed much more fully in the text. There are major differences between ultrasonic and electromagnetic waves both in respect of the basic differential equations and of the boundary conditions. On the other hand the mathematical methods used are essentially similar and the great wealth of material available in the electromagnetic field should yield results of value to the present subject. The author has preferred to develop his subject in a way which requires no knowledge of electromagnetic theory: this is perhaps desirable for the beginner, but the serious student should be aware of the closely related work in other fields.

Considered as a whole, the book is a most useful introduction to an interesting subject. It contains a lengthy list of references and useful appendices in which the key formulae are collected together.

J. BROWN

Progress in Semiconductors, Vol. 5

Edited by A. F. Gibson, F. A. Kröger and R. E. Burgess. 316 pp. 129 figs. Royal 8vo. Heywood & Co. 1960. Price 63s.

IT would have been plausible, but premature, if those interested in semiconductors had concluded after the publication of Vol. 4 of this series, that the science of semiconductors was 'thinning out', and that the more general aspects of semiconductors were now known and had been fairly described in previous volumes. Any person who thought this must have noticed his error when seeing the present volume. One could hardly pack more solid 'meat' into a book, and it could hardly be of better quality and presentation. This is a very relevant and vital book, in some aspects the best of the series. The editors are certainly to be congratulated.

Dr. Watkins contributes a lucid and informative article about the electrical properties of semiconductor surfaces.

EE 31 117 *for further details*

CHAPMAN & HALL

Electronic Maintainability

Edited by

F. L. ANKENBRANDT

Distributed in association with Reinhold Publishing Corporation for Engineering Publishers, N.J.

This book, based on the Third Electronic Industries Association Conference on Maintainability of Electronic Equipment, contains an authoritative discussion of the developments which have been changing maintainability from the vaguely practised art of yesterday to the rigorous science of today. The subject matter ranges from the maintenance problems of space flight to the determination of adequate working space for electronic technicians.

Illustrated 80s. net

37 ESSEX STREET, LONDON, W.C.2

This will be of interest to both the physicist who wants to study semiconductors, as well as the engineer who wants to use them in circuits. The complicated details of the absorption edge spectrum in germanium and silicon, which give much information about the band structure and other basic properties of these materials, are described by Dr. McLean, who has made a major original contribution to the research in this field. A corresponding article of magneto-optical phenomena by Dr. Lax and Dr. Zwerdling is complementary to the one by Dr. McLean. The various aspects of magneto-optical effects are not only enlarging an understanding of semiconductors but also promise to serve as the background to future sophisticated uses of solids.

Dr. Mooser and Dr. Pearson develop the fascinating story of the chemical bond in semiconductors and do much to clarify the connexion between the band model and the approach via the geometrical configuration of electron orbitals.

Dr. Moss describes indium antimonide, the first 3-5 compound that has found extensive practical use.

There are also articles on the physics of the thermal conductivity of semiconductors and the properties of graphite crystals.

The volume is thus of the greatest use to physicists and chemists who are interested in the latest and most specialized aspects of semiconductor—and solid state physics, but the alert electrical engineer might find much of interest in it.

Printing and figures are of the usual high standard of the series.

K. HOSELITZ

Dictionary of Electronics

By H. Carter. 377 pp. 236 figs. Crown 8vo. George Newnes Ltd. 1960. Price 35s.

THE field of electronics has widened to the extent that, with the new terms introduced with specific branches of the subject, the student and even the scientist may find it difficult to keep up with the new developments. It is with this in mind that this illustrated dictionary is presented.

The book gives definitions from many branches of electronics, including radio, television, communications and radar and is intended for engineers, students, technicians and apprentices who work or are interested in electronic terminology.

The Relay Guide

By R. Auger. 383 pp. Crown 4to. Reinhold Publishing Co. and Chapman and Hall Ltd. 1960. Price 80s.

THIS complete reference includes virtually all published data on hundreds of available models of relays from approximately 200 manufacturers. The book contains 23 chapters of relay illustrations and descriptions according to relay type and includes data from the literature of American manufacturers of relays.

Where one relay has many variations, the book provides tables or lists of them next to the basic model. A relay which belongs to more than one type is classified into the most specialized chapter in which it fits. The guide presents application data, relay circuits, arc suppression information, relay definitions and terms in addition to relay descriptions. An appendix presents complete information on relay testing techniques.

Servomechanisms

By P. L. Taylor. 407 pp. 248 figs. Royal 8vo. Longmans Green and Co. 1960. Price 42s.

ASCRIBE once said, rather nastily, that those that can, do; and those that can't, teach. An invasion of books fluttering in on a westerly wind still with the faint whiff of mineograph about them so recently have they come from the lecture notes has rather brought this comment to mind. Now as an antidote comes Mr. Taylor with a book which is really about servomechanisms, as apposed to amorphous control theory and through whose pages speaks the voice of practical experience.

The arrangement of the book is unusual in that we get to page 345 before we hear about Nyquists Criterion of Stability. This is due to the fact that the book is mainly about servomechanism components; d.c. machines; rotary amplifiers; a.c. systems; motors both electric and hydraulic. It is only in the concluding 100 pages concerned with analysis of systems. The early part of the book forms a gentle lead-in to the main sections in the form of a general review of what one might dub, allied topics; data transmission, data computation including a brief comment on digital machine organization and a more extensive treatment of analogue operations. Simple transients by the operator D method allow introduction of error classification and thence to the concept of feedback. At chapter six sleeves are rolled up and we have the author at his best on machines and motors, and very refreshing it is. We go into the highways and byways, Magical Magnicons and linear stroke motors; the lot!

Perhaps it is a bit carping to suggest that an excellent section on rotary machines comes a bit late in the day. For some time now magnetic amplifiers have been making inroads into the territory of the rotary amplifier; a process which will be hastened by the arrival of 4-layer semiconductor devices. Eager to find how the author views this intrusion we turn to the next chapter on Static Amplifiers, but are disappointed to find no mention of either.

So to the section on System Analysis, which has a classical introduction; linear systems, complex function theory for quality, Laplace transform, transient response, harmonic response. The author is up-to-the-minute in including the root-locus method; he does some worthwhile examples and gives his opinion of the relative merits of the various methods of analysis. The author is not a root-locus man. Systematic methods of design using the root-locus method have been worked out although they are not yet very widely known. One should in fairness master these before making comparisons.

In conclusion this is a book with an individual approach to servomechanisms. While some of it constitutes the standard text the author has clearly been actively engaged in the practical aspects of the work and his examples are well chosen and his commentary based on experience. Although other books have included "Servomechanisms" in their title none have been so single mindedly or exhaustively about servomechanisms.

J. H. WESTCOTT

Semiconductor Abstracts

419 pp. Demy 4to. John Wiley and Sons, London and New York. 1960. Price 96s.

THIS book was compiled by the Battelle Memorial Institute and contains abstracts of literature on semiconducting and luminescent materials and their applications.

Basic Synchros and Servomechanisms, Parts 1 and 2

118 and 111 pp. Medium 8vo. Technical Press Ltd. 1960. Price 16s each.

IT is the purpose of these two manuals to describe and illustrate, in a simple way, the fundamental characteristics of two groups of devices, synchros and servomechanisms, used in many types of military equipment.

Short News Items

Graduate Courses in Information Theory and Theory of Electrical Machinery will again be held in the Electrical Engineering Department of the University of Birmingham. Both courses last 12 months, 1 October 1961 to 30 September 1962, and students who already hold a first degree of an approved University may qualify for the degree of M.Sc. by examination. The Graduate Course in Information Engineering will be running for the fifth time, and on the same general syllabus as in 1960-61. The course which for 1960-61 was entitled "Theory of Electrical Machinery" will in future be known as "Electrical Machines: Electromechanical Energy Conversion and Automatic Control". The fee for these courses is £18 and application should be made to the Graduate Supervisor, Electrical Engineering Department, The University, Edgbaston, Birmingham 15.

The Annual Conference of the Electronics Group of the Association of Special Libraries and Information Bureaux will be held at Ashridge College, Berkhamsted from 21 to 23 April. Papers will be given on electronics, librarianship and information work. Among the speakers will be Mr. G. W. A. Dummer, Royal Radar Establishment, on "Modern developments in components for electronic equipment". The fee for the whole conference will be £7 and applications should be made to Mr. N. E. C. Isotta, Ministry of Aviation, T.I.L.2, First Avenue House, High Holborn, London, W.C.1.

The British National Committee of C.I.G.R.E. (Conference Internationale des Grands Reseaux Electroniques) has now moved to its new office accommodation at the Electrical Research Association, Cleeve Road, Leatherhead, Surrey.

Airfield surveillance radar for the R.A.F. has been ordered from Cossor Radar & Electronics Limited by the Ministry of Aviation following an extensive technical and operational evaluation by the Air Ministry and Ministry of Aviation. The contract covers a substantial number of static Cossor CR.787 installations for use at R.A.F. airfields in this country and abroad. It follows an earlier contract for a smaller number of the same Cossor equipment in mobile form. The mobile version, complete with its power supply unit, can be transported in a single aircraft and brought into operation within a few hours of landing. Much of the static installation will consist of duplicated S-band transmitter/receivers and radar displays. The Cossor CR.787 incorporates devices for the elimination of echoes from fixed objects such as mountains and buildings, and also achieves a high degree of discrimination against rain.

Th BBC's new low-power television station near Swingate, which shares the site of the Air Ministry radio station on the cliffs some 400ft above Dover, was brought into operation on 1 February. The new station is equipped with two 500W vision and two 125W sound transmitters manufactured by Standard Telephones & Cables Limited. One set of equipment is a reserve for use in the event of a fault on the other. The power is the maximum that can be used if interference with other BBC and Continental television stations, with which Dover must share a frequency channel in Band 1, is kept to acceptable limits. Like the temporary station which it has replaced the new station will transmit on Channel 2 (vision 51·75Mc/s offset by −6·75kc/s, sound 48·25Mc/s offset by +31·5kc/s). The transmissions will be vertically polarized.

The Fourth International Conference on Medical Electronics is to be held at the Waldorf Astoria, New York, from 16 to 21 July. The conference, which is combined with the 14th annual conference on Electrical Techniques in Medicine and Biology is sponsored by the Joint Executive Committee on Medicine and Biology (IRE, AIEE, ISA) under the auspices of the International Federation for Medical Electronics. An exhibition will be held at the same time as the conference and will feature examples of scientific instrumentation, diagnostic and therapeutic equipment and the latest techniques in the medical electronic and electrical fields. Papers are now invited for presentation at the conference and intending authors are requested to submit abstracts of 300 words for preliminary review and a summary of 50 words before 1 April to Dr. Herman P. Schwan, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia 4, U.S.A. Abstracts and summaries may be in English, French, German or Russian. Full particulars of the conference and exhibition may be obtained from the Institute of Radio Engineers, 1 East 79th Street, New York, N.Y.

The Pakistan Posts & Telegraphs Department is to be supplied with a considerable amount of Marconi high power radio communications equipment as a result of orders recently placed on this company by the British Government through the Crown Agents. The consulting engineers for the project are Messrs. Preece, Carde & Rider. The installations will make a further contribution to improving radio communications with another CENTO country: last year Iran and Turkey were the recipients of much Marconi h.f. radio equipment as CENTO aid. The equipment now ordered comprises two 30kW high frequency independent sideband transmitters type HS51, together with their associated i.s.b. drive units, and five dual diversity telegraph high frequency receivers type HR11, and accessories.

A new telephone trunk coaxial line system recently introduced between Oxford and Birmingham makes it possible to carry 2 700 telephone circuits over two coaxial pairs in place of the previous maximum of 960. As an alternative, the new system can carry 960 telephone circuits and a high quality television transmission. Similar systems are now being installed between London and Oxford and Bristol and Cardiff. At the terminal stations, when the line is used for telephony, the telephone channels are stacked into the line frequency band of 312kc/s to 12·34Mc/s by frequency changing. The signals are amplified every three miles along the route and at each amplifying point the gain is controlled automatically to compensate for the effects of changes of temperature of the cable. Power for the intermediate stations is fed along the same conductors that carry the speech signals. Up to 13 stations can be fed from any power feeding point. The Oxford-Birmingham route is fed with power from the terminal stations only. The voltage applied to the cable is 1 000-0-1 000, i.e. 1 000V wire to earth, 2 000V between conductors. A comprehensive system of alarms ensures that any fault condition is brought immediately to the notice of the staff at the terminal stations. The Oxford-Birmingham and London-Oxford line systems were designed and manufactured by Standard Telephone and Cables Ltd, and the Bristol-Cardiff system by the Automatic Telephone and Electric Co. Ltd.

The B.B.C. v.h.f. sound broadcasting stations at Les Platons, in the Channel Islands and at Londonderry in Northern Ireland, are now in an advanced stage of construction. They are two of the ten additional stations announced in June 1959 forming the first stage of the BBC's plan

for extending and improving the coverage of its v.h.f. sound service, which is already available to 97 per cent of the population of the United Kingdom. The second stage of this plan, providing for a further 11 v.h.f. sound stations, was announced in May last year. Both of these new stations are sharing the sites and aerial towers of existing BBC television stations. Les Platons will radiate the West-of-England Home Service, the Light Programme, and the Third Programme with Network Three. These programmes will be received by radio from the North Hessary Tor or Rowridge v.h.f. stations, for which purpose special receiving aerials are to be installed on a 150ft tower which has yet to be erected. Londonderry will radiate the Northern Ireland Home Service, the Light Programme, and the Third Programme with Network Three. These programmes will be fed by Post Office cable from a special receiving site at Glenderowen where they will be received by radio. It is expected that both of these station will come into operation during the summer of this year.

The Institute of Radio Engineers have elected six directors to serve on the Board in 1961 for a one-year term. Succeeding the late W. R. G. Baker, Stuart L. Bailey, president of Jansky and Bailey Inc., Washington, D.C., was elected treasurer. Haraden Pratt, engineering consultant, and Ferdinand Hamburger, Jr, professor and chairman of the Department of Electrical Engineering, The John Hopkins University, Baltimore, Md., were re-elected to the offices of secretary and editor respectively. All three officers also serve as directors. Alfred N. Goldsmith, consulting engineer and editor emeritus of the IRE, and Patrick E. Haggerty, president of Texas Instruments Inc., Dallas, Texas, were re-elected as directors. Also elected as director was Daniel E. Noble, vice-president and director in charge of Communications, Semiconductor and Military Electronic Divisions, Motorola Inc., Scottsdale, Ariz.

More than 250 exhibitors have applied for stand space at the Radio and Electronic Component Show to be held at Olympia, London, on 30 May to 2 June. The Component Show which is organized by the Radio and Electronic Component Manufacturers' Federation will now occupy a floor space of more than 70 000ft².

Coventry Municipal Airport at Baginton has recently been equipped with Decca type 424 airfield control radar. The installation of this all-weather landing aid is in anticipation of considerably increased traffic this summer and to meet BEA requirements when Coventry is used as an alternative for scheduled services. Other improvements completed in the past year include a 5 300ft runway, cathode-ray d.f. equipment and high and low intensity approach lighting. Simplicity of operation and maintenance, coupled with good all round operational performance, make the type 424 suitable as a landing aid for airports like Coventry where the amount of traffic, while not justifying the installation of costly ground controlled approach equipment, nevertheless calls for a simple and reliable radar aid to monitor approaching aircraft and provide final approach data for landings in adverse conditions.

Automatic Mail Segregating, Grading and Facing Equipment, similar to the type ordered by the G.P.O., has been ordered by the Canadian Post Office from Elliott Brothers (London) Limited, a member of the Elliott-Automation Group. This is the first substantial export order for this type of equipment. The equipment, which is fully automatic, takes the mail just as it is received from the posting boxes and sorts it electronically into orderly bundles, all facing the same way and graded, according to size and class of mail, so that it is ready to be sorted according to its destination. Similar equipment, but adapted to the British mail, has been operating for some years in the Southampton main sorting office and will shortly be installed in other offices in the United Kingdom. Elliott-Automation emphasizes that full credit for the part they have played in the securing of this order must be given to the British Post Office and their engineers, for it is upon their pioneering work that this new export trade is being built up.

The Tata Institute of Fundamental Research of India, has ordered a complete high altitude meteorological research system, including high altitude receivers, tone generators, and transmitters, from BEME Telecommunications Ltd, of Hythe, Hants. BEME Telecommunications, who are part of the Derritron Electronics Group, have just joined the Society of British Aircraft Constructors.

The Bristol Branch of the British Computer Society is holding a one-day conference at the Engineering Department of The University of Bristol on 28 March to investigate the possibility of electronic computing centres being set up, owned by, and operated on behalf of, groups of small member firms and organizations. The Conference will include a description of a co-operative installation, The Centre for Electronic Administration, which has been established in the Netherlands. Particulars of the Conference can be obtained from Mr. O. B. Chedzay, Brockholm, Cheddar Road, Axbridge, Somerset.

The Sixth International Instrument Show sponsored by B. & K. Laboratories Ltd, 4 Tilney Street, Park Lane, London, will be held at the Company's office from 19 to 23 June. Fifty exhibitors from ten countries will be participating in this Exhibition which will cover an area of 2 500ft².

British Railways are installing electronic computers at Stratford and Doncaster, the two main workshop areas in the Eastern Region. The computers will be used to provide detailed stock data for some 90 000 different items and also for the wage calculations for about 10 000 employees in the Stratford and Doncaster workshop areas. The installations, which consist of one type 555 Plugged Program Computer at each centre, are being supplied together with their tabulators, etc., by International Computers & Tabulators Ltd.

An Anglo-American agreement has been effected between Microcell Ltd and Emerson & Cuming Inc. for the sale and distribution in the U.K. of the American company's range of plastics designed specifically for the electronic industry. The range includes energy absorbing materials for the v.h.f., u.h.f. and microwave bands, plastic and ceramic foams with known dielectric constants, casting resins, a passive reflector of radar energy and a lead loaded nuclear radiation shielding material.

Lancashire Dynamo Electronic Products Ltd of Rugeley, Staffordshire—a member of the Metal Industries Group—has concluded a licence agreement with the Emerson Electric Manufacturing Co. of St. Louis, Missouri, under which the American company will have the right to manufacture in the United States on a royalty basis the former company's range of industrial electronic control equipment.

The Electronic Computer Exhibition will be held at Olympia from 3 to 12 October 1961 and in conjunction with it will be a Business Computer Symposium, from 4 to 6 October. The Exhibition and Symposium, which are organized jointly by the Electronic Engineering Association, and the Office Appliance and Business Equipment Trade Association, will have as a theme 'The Work of the New Generation of Computers'.

The National Aerospace Electronics Conference will be held in Dayton, Ohio, U.S.A., from 8 to 10 May 1961. The Conference is sponsored by the Professional Group on Aeronautical and Navigational Electronics and the Dayton Section of the IRE with participation by the Institute of Aerospace Sciences. Further details of the conference can be obtained from, 1961 NAECON Publicity, 4663 Hedgewood Avenue, Dayton 16, Ohio.

Electronic Equipment at

THE PHYSICAL SOCIETY EXHIBITION

A description, compiled from information supplied by the manufacturers, of a small selection of the electronic equipment, exhibited at the 45th Physical Society Exhibition, held in London from 16-20 January.

(Voir page 191 pour la traduction en français ; Deutsche Übersetzung Seite 198)

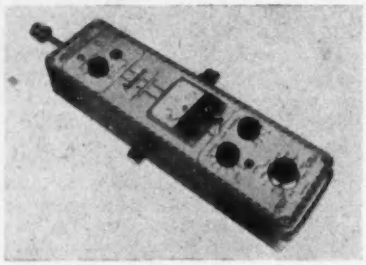
ADVANCE COMPONENTS LTD

Roebuck Road, Hainault, Ilford, Essex

SOUND SPECTROMETER

(Illustrated below)

The Advance sound spectrometer is an accurate, stable, lightweight instrument with its own battery power supply, and completely self-contained. This instrument is of advanced design and is suitable for sound measurement problems and analysis. With the built-in octave band filters, rapid analysis of noises having complex spectra is possible. It can also be used with a suitable vibration pick-up for vibration analysis in the audio frequency range. The SPM.1 is particularly suited for noise measurements of aircraft, vehicles, machinery,



and for the analysis of office noise, where the speech interference level is a significant factor.

The instrument consists of a very small crystal microphone; a six-stage amplifier, stabilized by heavy negative feedback; 8 band-pass filters, which can be switched in at choice and a moving-coil meter with a decibel scale. An attenuator is built in with 5 steps of 10dB covering a range of 30 to 80dB, with an additional attenuator of 3 steps of 20dB covering a range of 0 to 60dB. Including the meter reading the total range of the apparatus is from 20dB to 150dB relative to the standard sound pressure reference level of $2 \times 10^{-4}\mu b$ ($=2\times10^{3}$ N/m^2). Sounds with frequencies in the range from 20c/s to 12kc/s can be measured, with the aid of the built-in filter, analysed into octave bands. The condition of the built-in batteries can be tested with the moving-coil meter.

EE 31 751 *for further details*

AIRMEC LTD

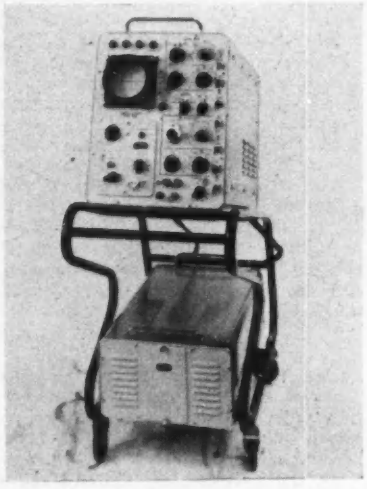
High Wycombe, Buckinghamshire

HIGH SPEED OSCILLOSCOPE

(Illustrated above right)

The type 294 oscilloscope is a versatile laboratory instrument, its wide range of sweep speeds and the wide frequency response (d.c. to 50Mc/s) and short rise-time of the Y amplifier making it suitable for high speed pulse applications. Accurate calibration of the time-bases and deflexion amplifier, the provision of time and voltage markers, and comprehensive sweep delaying and triggering facilities make the instrument suitable for general laboratory measurements.

Pulse outputs synchronized to the internal time-bases facilitate operation in conjunction with complex electronic equipment, and a single-shot sweep, variable edge-lighting of the graticule,



and switched alternative p.d.a. potentials provide for ease in photography of the trace. Illuminated beam-position indicators and colour-coded logically-sited controls further make for simple and foolproof operation.

The complete equipment, developed by a well-known French company and manufactured under licence by Airmec, consists of the display unit mounted at an angle for easy viewing on a tubular steel trolley, fitted with castors and carrying the power unit in its base.

EE 31 752 *for further details*

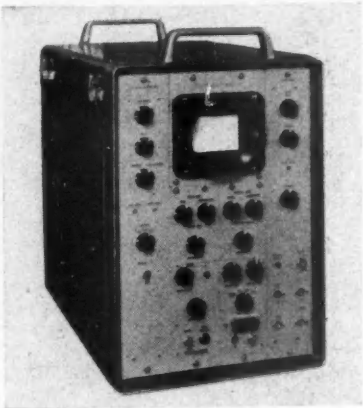
CAWKELL RESEARCH & ELECTRONICS LTD

Scotts Road, Southall, Middlesex

TELEVISION STORAGE OSCILLOSCOPE

(Illustrated above right)

The Tele-Remscope is a new type of picture monitor for use with closed circuit television systems. Its main feature is that the picture may be 'frozen,' at any time, simply by depressing a button or by operating a switch.



The Tele-Remscope will operate on 405, or 625 lines, 50 fields/sec or 525 lines, 60 fields/sec, and requires a positive-going 1·5V video input. Any number of fields from 1 to 4 may be stored and displayed for up to 15 minutes on the face of an English Electric E702 storage tube. The screen is 10cm in diameter and a yellow/green (P20) fluorescence is produced.

EE 31 753 *for further details*

DAWE INSTRUMENTS LTD

99-101 Uxbridge Road, Ealing, London, W.5

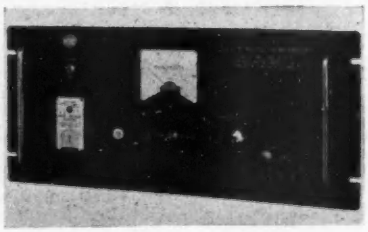
U.L.F. NOISE GENERATOR

(Illustrated below)

The u.l.f. noise generator type 418 provides electrical noise with a frequency spectrum uniform to within ±0·5dB from 0 to 200c/s.

The noise source in the instrument is a thyratron valve giving electrical noise uniform in spectrum in the audio frequency range. The noise output is passed through a relatively wideband filter centred at 2kc/s to a modulator circuit where it is mixed with the output from a local, fixed frequency oscillator operating at 2kc/s.

The output from the modulator is passed through a low-pass filter to eliminate the high frequency modulation products. The low frequency signal is



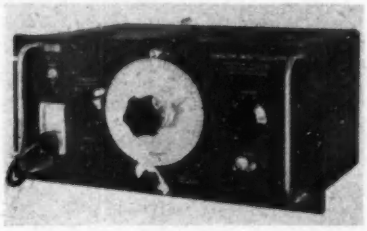
amplified in a d.c. coupled amplifier with a low impedance cathode-follower output feeding the output terminals and an indicating meter. The meter is calibrated to read r.m.s. values of random noise. The output level is continuously adjustable by a potentiometer varying the gain of the amplifier. High stability of the set output level and low d.c. drift are obtained by using stabilized high and low tension supplies and a generous amount of negative feedback in the amplifier. The wide dynamic range of the amplifier ensures random amplitude distribution with negligible clipping of the waveform up to the full rated output.

EE 31 754 *for further details*

AUTOMATIC L.F. OSCILLATOR

(Illustrated below)

The type 444 automatic l.f. sweep oscillator fulfils the need for a low distortion resistance-capacitance tuned oscillator covering 5c/s to 5kc/s, in a single range. The oscillator provides constant voltage output and the frequency scale calibration is truly logarithmic. The frequency sweep control is driven by a self-contained motor arranged to give various sweep rates between any desired frequency limits. The direction of frequency



sweep can be set to reverse automatically at the limiting frequencies. Alternatively it can be reversed or the sweep stopped at any instant by remote control.

Essentially the circuit consists of a frequency controlling bridge feeding a balanced push-pull amplifier with a cathode-follower output.

The frequency controlling network consists of a modified form of Wien bridge in which the resistive arms have been replaced by complex resistance-capacitance networks. These extend the constant phase shift frequency range over a ratio of 1000:1 with a 10:1 capacitance ratio of the tuning capacitor. The tuning capacitor has a rotor shaft which can turn continuously and has been specially designed to provide a truly logarithmic scale calibration.

A motor drive and gearbox provide six sweep rates between 0·2 and 10 octaves per minute and adjustable limit switches are arranged so that the frequency can be swept through any part of the range.

The sweep can also be controlled by means of the remote control assembly type 444/1. The frequency can be swept forward or reversed or the sweep stopped at any instant. Alternatively the frequency dial can be set by hand, to any desired frequency.

The signal from the bridge is fed into the balanced push-pull amplifier which is directly coupled to the cathode-follower stage. Negative feedback is applied from the cathodes of the output stage to the grids of the amplifier valves. A thermally sensitive resistance element is incorporated in the resistive arms of the bridge to stabilize the amplitude of oscillation at a level within the linear range of the balanced amplifier. This, together with the large amount of negative feedback at harmonic frequencies, ensures good stability and low distortion of the output sine wave.

Within the overall negative feedback loop a controlled amount of positive feedback is applied over the output stage alone, to reduce its ouput impedance virtually to zero. The output terminals are fed from a two gang potentiometer connected to the cathode-follower outputs.

Push-pull outputs of up to 12V into 10kΩ are available at the output terminals. The output levels are continuously variable from maximum to zero.

EE 31 755 *for further details*

DYNATRON RADIO LTD

Maidenhead, Berkshire

NUCLEAR TEST SET

The test set type N107 comprises a combined pulse generator and measuring oscilloscope and is designed to provide the necessary services for maintenance of the commonly used instruments in the nucleonic field, e.g. pulse amplifiers, discriminators, scalers, ratemeters and pulse height analysers. A master multivibrator controls the pulse recurrence frequency of the pair of pulses.

The master pulse recurrence frequency signal triggers (1) a pulse width generator, and (2) a sawtooth run down stage. The fixed pulse generated in (1) is amplitude limited and then fed to an amplitude control pair, enabling positive going or negative going pulses to be chosen. A double cathode-follower feeds either the output terminal of the test set or a further attenuator. The sawtooth initiated in (2) provides an X sweep for the oscilloscope X amplifier, and also feeds into an amplitude gate. When the sawtooth crosses the gate level (set by pulse separation control) a pulse width generator, similar to (1), produces the moveable (second) pulse, which receives the same treatment as the first (fixed) pulse, i.e. limited, fed to an amplitude control pair and on to the output cathode-followers. The full action of the pulse generator provides a pair of pulses, positive going or negative going, independently controllable in width and amplitude, with variable separation between them. If not required, either the fixed pulse, or the second movable pulse can be switched off.

The unit is completed by a Y amplifier, switched to enable a wideband response at medium gain, or a high gain over a restricted bandwidth. Amplitude is measured by a Y shift meter system

EE 31 756 *for further details*

E.M.I. ELECTRONICS LTD

Hayes, Middlesex

HIGH GAIN AMPLIFIER

The high gain amplifier type 7/5 is one of a range of plug-in sub-units produced for use with the W.M.16 oscilloscope.

It offers all the facilities provided by the wideband amplifier 7/1 and, in addition, the gain can be increased by a factor of 10, under a.c. coupled conditions, to give a maximum sensitivity of 5mV/cm at reduced bandwidth.

The high gain amplifier fits into the front panel receptacle of the W.M.16 and all necessary supplies are derived from the main oscilloscope.

A three-position input selector switch provides the following bandwidth-sensitivity combinations:

D.C.: Rise-time 10mμsec; bandwidth d.c. to 40Mc/s; sensitivity 50mV/cm to 20V/cm in nine switched and calibrated ranges.

A.C.: Rise-time 10mμsec; bandwidth 3c/s to 40Mc/s; sensitivity 50mV/cm to 20V/cm.

A.C. × 10: Rise-time 16mμsec; sensitivity 5mV/cm to 2V/cm in nine switched and calibrated ranges; input time-constant 0·05sec.

EE 31 757 *for further details*

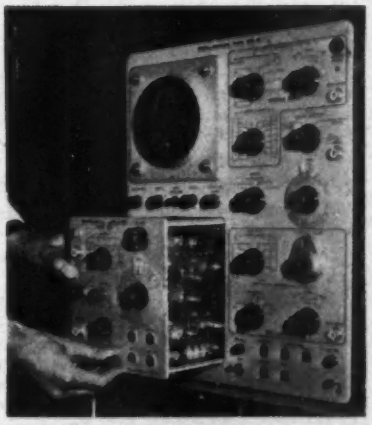
DIFFERENTIAL AMPLIFIER

(Illustrated below)

The differential amplifier type 7/6 is another plug-in unit for the W.M.16 oscilloscope and provides facilities for viewing two inputs either separately or differentially, either a.c. or d.c. coupled. Amplitude measurements can be made by dial or graticule, except when input B is being used on d.c. In this position measurement by graticule is provided.

Each channel has separate attenuators permitting a variation in sensitivity of 50mV/cm to 20V/cm in nine ranges. A fine gain control is provided which permits continuous adjustment between attenuator settings.

The bandwidth is d.c. to 25Mc/s or 4c/s to 25Mc/s and the rise-time 16mμsec. The rejection ratio is better than 100 : 1 over the pass-band d.c. coupled and better than 100 : 1 from 10c/s to 25Mc/s when a.c. coupled, at full gain.



EE 31 758 *for further details*

ELECTRONIC TUBES LTD

Kingsmead Works, High Wycombe, Buckinghamshire

STORAGE PHOSPHORS

A demonstration showed the properties of a normal cathode-ray tube when fitted with a new screen material.

As the screen is first excited there is a blue fluorescence similar to that of a normal, two layer, long afterglow phosphor. Following this there is an afterglow of comparable length to that obtained with the two layer phosphor, except that the afterglow of this screen is green in colour.

Even after the afterglow has completely died away, however, further information can be obtained from this screen. A certain amount of energy remains stored within the phosphor where it has been excited, and this can be released with the aid of infra-red illumination. The visual intensity of the stored image is dependent upon the intensity of the infra-red source, and so is the time available for viewing before this image is erased. As a specific amount of energy is available for release, increasing the infra-red source intensity decreases the viewing time and vice versa.

A further useful feature is that the stored image need not be viewed to extinction in one operation. Several brief viewings can be taken in succession, if necessary spaced some minutes apart.

Naturally with a storage mechanism such as this, the stored energy is directly dependent upon the energy of excitation. As the storage efficiency is relatively poor its use at high writing speeds is impossible. Neither is it recommended for use in conjunction with low voltage tubes, due to the low energies involved.

EE 31 759 *for further details*

ELLIOTT BROTHERS (LONDON) LTD

Century Works, Lewisham, London, S.E.19

AUTOMATIC CIRCUIT CHECKING EQUIPMENT

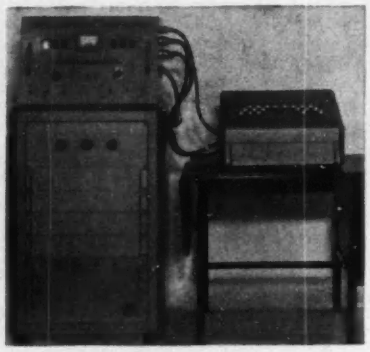
(Illustrated above right)

This equipment has been designed to facilitate the routine checking of complex cableforms, or similar constructions, completely automatically by programming the test requirements into the machine.

The model demonstrated is capable of carrying out the following tests, with up to 600 terminations. Each termination is checked against every other termination.

(1) Resistance 0 to 1000Ω.
(2) Continuity not greater than 0·5Ω.
(3) Insulation between lines greater than 20MΩ.
(4) Insulation to earth greater than 20MΩ.

Any of the above tests can be called up for any particular pair of terminations by a predetermined programme. The instructions are 'written' on 1in magnetic tape in sympathy with a cable or termination schedule which applies to the equipment under test. The equipment is connected to the A.C.C.E. in a



standard numerical sequence which coincides with the termination schedule and programme numbering.

The number of possible combinations with 600 terminations is 180 300. Only 120in of tape are needed to accommodate all possible programme material.

Subsequent development will enable the machine to check almost any electronic/electrical assembly with a minimum of work. An automatic fault recorder, in the form of a coded printout, is under development.

EE 31 760 *for further details*

STANDARD FREQUENCY RECEIVER

This instrument is designed to receive the Droitwich 200kc/s standard transmission which is correct to within approximately 20 parts in 10^9 and has the added advantage that it is compared almost daily, at 10.30 G.M.T., with the National Physical Laboratory's caesium resonator. The output of this unit is completely unaffected by modulation.

The standard frequency monitor unit produces the following frequencies from a high impedance source: sine waves of 5V peak-to-peak at 50,100,200 and 400c/s and 20 and 200kc/s; square waves of 2V peak-to-peak at 50,100,200 and 400c/s.

Other multiple low frequencies can be supplied on request except in the case of the 200kc/s and 20kc/s outputs.

Two variable gain amplifiers, which can be switched to any of the low frequency sources, enable other power apparatus to be driven. This output is up to 20V r.m.s. A monitoring loudspeaker is also provided.

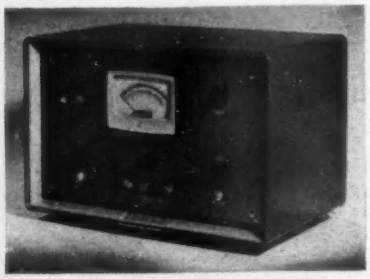
EE 31 761 *for further details*

RATIO-INDICATING AMPLIFIER

(Illustrated above right)

This is a selective amplifier in which the gain can be controlled by means of an electrical potential. The amplifier is followed by a bridge rectifier and indicating meter.

By means of an external switch circuit, the rectified output can be fed back through a d.c. amplifier to control the gain of the system. The meter indication will be constant within 1 per cent for a range of input voltage of over 50dB when the switch is closed. If the switch is then opened, the amplifier gain is held substantially constant for a considerable



length of time, by means of a circuit having a time-constant of the order of half an hour. Any change in the level of the input signal will then be registered on the meter.

EE 31 762 *for further details*

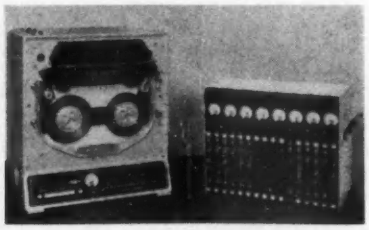
MULTI-CHANNEL TAPE RECORDER

(Illustrated below)

This instrument incorporates a tape transport system using dual capstans and take-up assemblies. Five tape speeds are available, selected by push-button controls, and at 30in/sec it is possible to handle frequencies up to 75kc/s.

A maximum recording time of nearly three days is available using sixteen tracks on 1in thin-base tape at 1⅞in/sec. Automatic reversal is accommodated by duplication of record and playback heads, five plug-in heads are standard equipment. Good wow and flutter characteristics are achieved by the design of the tape transport mechanism and the dual capstan drive isolates all tape in contact with the heads from disturbances which may be introduced via the take-up and take-off reels.

The equipment is fully transistorized, extensive use being made of printed circuits. Both direct recording and f.m. facilities are provided by modular plug-in units, and remote control facilities are provided for all functions. Principal applications of the recorder are in the guided weapon and aircraft fields for recording telemetered data and for the flight test role.



EE 31 763 *for further details*

ENGLISH ELECTRIC VALVE CO. LTD

Chelmsford, Essex

HIGH GAIN IMAGE INTENSIFIER

This high gain image intensifier tube comprises an input photo-cathode, five secondary emitting dynodes and an output fluorescent screen, and is operated in conjunction with its focusing solenoid, input and output optical systems and power supplies.

EE 31 115 *for further details*

NEW B9A EFFICIENCY DIODE

EDISWAN MAZDA U193

The U193 is a new Efficiency Diode, designed for use in line deflection stages of television receivers using 110° and 114° cathode ray tubes and has a maximum peak heater to cathode voltage rating of 5.5 kV as compared with 5 kV for the U191.

The valve is mounted on a B9A (noval) base with the cathode brought out to a top cap connection.

MAXIMUM DIMENSIONS (mm)

Diameter	22.2
Seated Height	75
Overall Length	82

TENTATIVE RATINGS AND DATA

Heater Current (amps)	I_h	0.3
Heater Voltage (volts)	V_h	19

Maximum Design Centre Ratings

Mean Anode Current (mA)	$I_{a\,(av)\,max}$	150
Peak Anode Current (mA)	$i_{a\,(pk)\,max}$	450
Peak Inverse Voltage (kV)	$PIV_{(max)}$	5.5*
Peak Heater to Cathode Voltage (heater negative) (kV)	$V_{h-k\,(max)}$	5.5*

* Rated for TV line scan where the duty cycle does not exceed 15% and the pulse duration does not exceed 15μs. An absolute rating of 6.6 kV must not be exceeded.

Inter-Electrode Capacitances (pF)

Anode to Heater and Cathode	$C_{a-h,\,k}$	6.6
Cathode to Heater and Anode	$C_{k-h,\,a}$	7.9

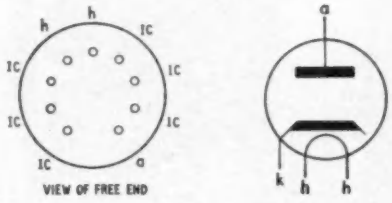
APPLICATION NOTES

The Ediswan Mazda U193 is designed specifically for use as the efficiency diode in line deflection stages of television receivers using 110° and 114° cathode ray tubes. It would normally be used in conjunction with line scanning output valves such as the 30P4 and 30P19 in energy recovery types of line scanning circuits in a.c./d.c. television receivers. The heater may be directly connected in the normal series chain as the insulation between heater and cathode is adequate to withstand the pulse voltages encountered in auto-transformer scanning circuits. This high voltage insulation generally results in high thermal inertia of the cathode, giving a much longer heating time than the remaining valves in a television receiver. In the U193, however, the thermal inertia has been reduced considerably so that there is only a delay of a few seconds between the warm-up of other valves in a receiver and the start of operation of the line scanning circuits. Besides reducing the waiting time for a picture to appear, this factor also alleviates problems of protection of valves where a line-gated system of automatic gain control is used.

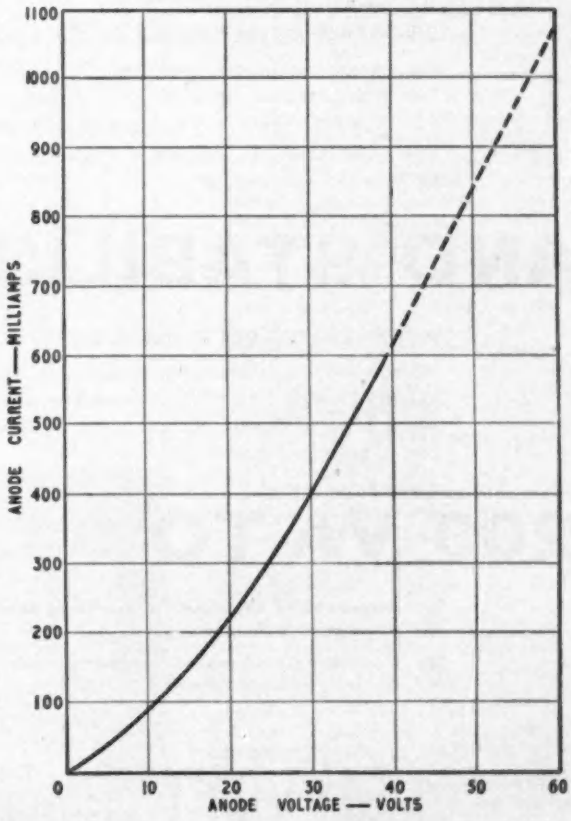
See "Aspects of Design No. 20 ('Wireless World' March 1960)—Efficiency Diodes for TV Line Output Stages" for notes on circuit considerations and limiting ratings.

Mounting Position: Unrestricted

Base: B9A (Noval) **Top Cap:** CT1—Cathode Connection



Characteristic Curve of Average Ediswan Mazda Valve Type U193



Associated Electrical Industries Ltd
Radio and Electronic Components Division
Technical Service Department
155 Charing Cross Road, London, W.C.2
Tel: GERrard 9797 Grams: Sieswan, Westcent, London

EDISWAN
MAZDA

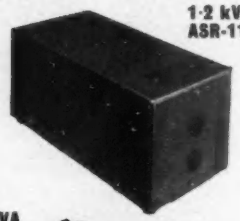
TA 15/103/5148

EE 31 119 *for further details*

Claude Lyons

COMPACT SERIES ASR & ATC.

Ingenious step principle. Small, light, inexpensive. Designed to provide adequate stabilisation for many applications, without distortion. 600 VA to 2·4 kVA. Normal or tropical finish.



1·2 kVA
ASR-1150

AC AUTOMATIC

1 kVA
BAVR-1000

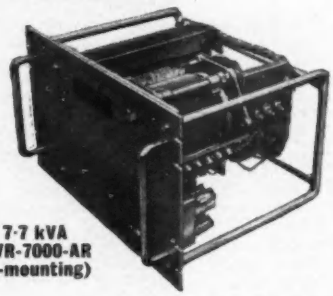
PRECISION ELECTRONIC SERIES BAVR.

Extremely rapid response. Very high accuracy of ±0·15%. Models for ratings of 200, 500, & 1000 VA. Normal or tropical finish.

VOLTAGE REGULATORS

HIGH-SPEED DISTORTIONLESS SERIES TCVR.

For precision equipment, computers, etc. Accuracy ±0·5%. Very high correction rate of 40 volts/sec. Large range, 2·2 to 12·7 kVA single-phase, 6·5 to 38·2 kVA three-phase. Cabinet or rack-mounting models. Normal or tropical finish. Can be made to Services' specifications, etc.

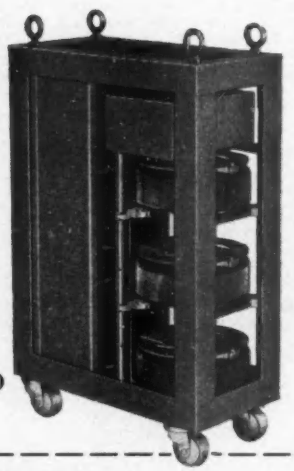


7·7 kVA
TCVR-7000-AR
(rack-mounting)

AND STABILISERS

DISTORTIONLESS SERIES BM & BMVR.

Wide industrial and laboratory applications. Accuracy ±0·5%. Very large range, 1·8 to 31·2 kVA single-phase, 6·5 to 94 kVA three-phase. Many models for rack-mounting. Normal or tropical finish. Can be made to Services' specifications, etc.



94 kVA
BM-751-C
(covers removed)

200 VA TO 94 KVA

- **Operation of all types independent of wide variations in frequency.**
- **Special models manufactured to customers' quantity requirements.**

Write for complete information.

Claude Lyons Ltd.

STABILISER DIVISION

VALLEY WORKS · HODDESDON · HERTS · TEL: HODDESDON 4541-6

CE 63/TA

The image to be intensified is focused on the photo-cathode at one end of the tube, and the photo-electrons are accelerated and focused on to the first thin film dynode. Secondary electrons, five or six to each primary, are emitted from the other side of the dynode and these are in turn accelerated and focused to the second dynode. This process is repeated at each dynode, and the secondaries emitted from the final dynode are accelerated on to a fluorescent screen to produce an intensified replica of the original weak light image.

Tubes have been made giving a photon gain of 100 000 to 200 000 a gain of 7000 being provided by the five stages of secondary electron multiplication and the remainder arising from the bombardment of the output fluorescent screen.

The usable diameter of the thin film dynodes is 1in. If desired, the picture may be reduced in size between the photo-cathode and the first dynode, so that the diameter of the input picture need not be limited to 1in. Similarly a larger picture may be formed on the screen if required.

EE 31 764 *for further details*

BISTABLE STORAGE C.R.T.

A new approach to the design of the storage target assembly has been used in the E710 bistable direct view storage tube. The use of the new technique involves far less risk of damage to the assembly should a high beam current be applied accidentally and so the associated circuits can be simplified.

This tube will store information indefinitely and allow the continuous or intermittent display of the stored waveform. Two or more signals can be stored and simultaneously displayed and instantly erased when no longer needed.

The E710 has a writing gun, electrostatically deflected and focused, which deposits a charge pattern on the storage mesh, the spot diameter being approximately 0·010in. A second gun, which floods the storage mesh continuously, maintains this signal and displays it on the phosphor.

EE 31 765 *for further details*

MARCONI INSTRUMENTS LTD

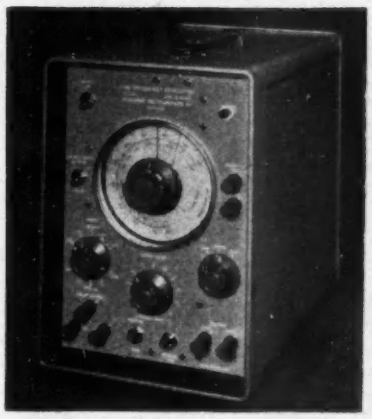
St. Albans, Hertfordshire

LOW FREQUENCY GENERATOR

(Illustrated above right)

This new generator delivers any of three switch selected waveforms—sine, square, or ramp, and is continuously variable over the frequency range 0·0033c/s to 1kc/s. This frequency range is covered in five overlapping bands. A built-in relay with heavy-duty change-over contacts wired to the front panel is operated by the square wave output at frequencies of up to 1c/s; this enables external devices to be switched on and off in a cyclic manner at the operating frequency.

The usefulness of this instrument as a timer is greatly increased by the provision of facilities for 'single-shot' operation. The timing cycle is initiated by a switch on the front panel, by an externally-generated pulse, or by external shorting contacts.



The TF 1382 employs an unconventional method of sine wave generation in that the waveform is electronically synthesized. The basic waveform is a sawtooth or ramp, which is available as one of the output waveforms. Rectification of the sawtooth produces a triangular waveshape (not available as an output). The triangular wave is then shaped by a circuit using Zener diodes which modify the waveform to produce a sine wave. The square wave output is derived from the triangular waveform via a bistable switching circuit.

EE 31 766 *for further details*

SUPPRESSED-ZERO VOLTMETER

(Illustrated below)

The TF 1377 is a potentiometric slide-back voltmeter for measuring absolute voltages up to 500V d.c. and changes as low as 1mV in the source under test. It can also be used as a conventional differential voltmeter with a range of ±1mV to ±50V.

In the slideback or suppressed-zero mode of operation, the source voltage is backed off against a potentiometer-controlled internal d.c. supply, using the centre-zero meter as null indicator. The absolute voltage of the source is indicated by the digital read-out of the potentiometer, and subsequent variations in voltage are shown on the meter. Small changes in large voltages can thus be measured with exceptional discrimination, accuracy and ease, avoiding the inconvenience of using complicated arrangements of external batteries for backing off the standing voltage.

In the differential mode the potentiometer is switched out of circuit, and small unknown voltages are indicated directly on the meter.

The instrument allows rapid accurate measurement of a wide range of d.c. voltages in the laboratory, production line, or in the field. Its precision incremental measurement system is particularly suitable for many applications such as regulation and stability tests on d.c. voltage sources; temperature coefficient measurements on semiconductors, resistors, etc.; direct strain-gauge tests; calibration of resistance thermometers and piezo-electric transducers; and regulation of generators. Rectifier probes are available to extend its usefulness to audio and r.f. measurement.'

EE 31 767 *for further details*

MORGAN CRUCIBLE CO. LTD

Battersea Church Road, London, S.W.11

WAVEGUIDE LOADS

These loads are designed to enable a radar station to 'stand-by' or 'test' on full power without transmitting a signal by which it can be detected, and without interference to other stations. Unlike previous materials used for this purpose, 'Termilode' which is based on silicon carbide can dissipate kilowatts of energy. The temperature limitation is set more by ionization of gas in the waveguide than by the material of the load. 1000°C will give a satisfactory performance. The various designs shown (with overall lengths varying from a few inches to several feet) are intended for air or liquid cooling. Dissipation up to 8kW has been achieved by water cooling.

EE 31 768 *for further details*

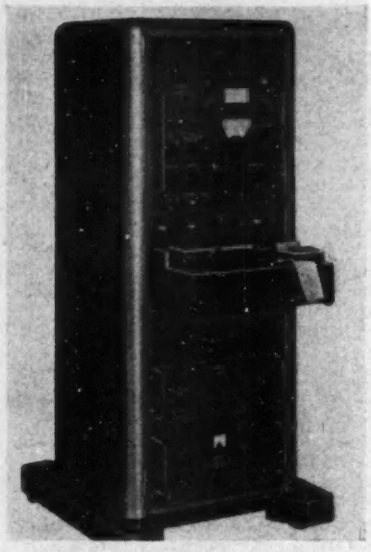
MUIRHEAD & CO. LTD

Beckenham, Kent

AUTOMATIC RECORDING WAVE ANALYSER

(Illustrated on page 188)

This instrument is for the automatic analysis and graphic recording of all types of noise and vibration signals from 'live' or magnetic tape recorded sources. The equipment performs amplitude/frequency analyses of steady signals and amplitude/frequency/time analyses of non-steady (time-varying) signals and is fully automatic over the entire frequency range of 10c/s to 19kc/s. To save time, the equipment can be made to scan only part of this frequency range if required. Three degrees of selectivity (⅓ octave, 5 per cent and 1·5 per cent) are available and in each case the percentage



bandwidth is constant at all frequencies; discrimination against unwanted frequencies is high. The maximum frequency error on the pre-printed output record paper does not exceed 1 per cent. Input signals can be in the range 10μV to 300V and with the input attenuator set for automatic operation a dynamic amplitude range of up to 70dB can be handled.

EE 31 769 *for further details*

NASH & THOMPSON LTD

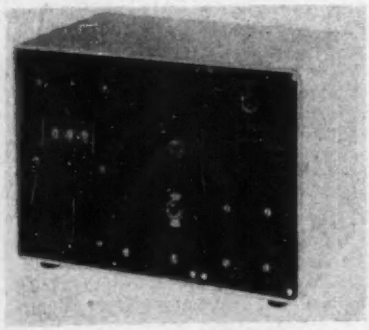
Hook Rise, Tolworth, Surrey

DIGITAL READ-OUT METER

(Illustrated below)

Designed to bridge the gap between the conventional moving-coil meter type of presentation and the more expensive digital voltmeters the new Nashton digital voltmeter provides an efficient and economic compromise. The press-to-read switch on the front panel operates the self-balancing bridge which is electromechanically linked to the indicator unit. The usual changes of digital readings take only a second or two and the counter requires 10sec to traverse its range. The equipment is made in two separate units mounted into a Nashton-major box. The digital unit is on the left-hand side and the functional unit, i.e., the voltmeter section, is on the right. The read-out is a mechanical counter with three digits ½in high. Voltage ranges are 1·00 to 9·99, 10·0 to 99·9 and 100 to 999, the accuracy being to better than ±1·2 per cent of actual reading ±1 digit. Right-hand units for resistance and capacitance are also available. Remote operation of the meter is possible.

EE 31 770 *for further details*



G. V. PLANER LTD

Windmill Road, Sunbury-on-Thames, Middlesex

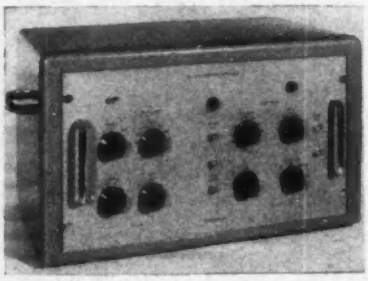
MILLIMICROSECOND PULSE GENERATOR

(Illustrated below)

This equipment has been designed primarily for switching-time determination in memory stores, e.g. of the thin alloy film type.

The pulse range covered extends from 2 to 200mμsec, the output being suitable to drive switching elements requiring currents of up to 13A. The output voltage can be varied from 1kV to below 1V.

The test specimen is mounted in a plug-in transmission measuring head with a suitable pick-up loop. The generator is designed to be operated with positive or negative outputs at a pulse repetition frequency of 50c/s, or with positive and negative outputs in varying ratios to enable switching or



non-switching to be observed simultaneously. Suitable oscilloscope points and a synchronizing output pulse are provided. The equipment is operated from 230V, 50c/s.

The generator can be used in conjunction either with a high speed or laboratory type oscilloscope.

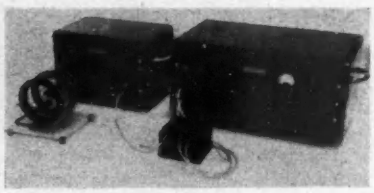
EE 31 771 *for further details*

HYSTERESIS LOOP TEST GEAR

(Illustrated above right)

This apparatus is designed for the display on a cathode-ray oscilloscope of hysteresis loops, and the determination of coercivity and remanence, of magnetic materials. The instrument has been developed for the testing of magnetic coatings and in particular of magnetic recording tape; it is also suitable for evaluating magnetic alloys, etc., in thin film, strip or wire form.

The equipment comprises a calibrated low noise amplifier and three alternative



measuring heads with their corresponding power supply units to cover the ranges:

(a) 50 to 2000 oersted. A grain oriented steel magnetic circuit with two pick-up coils in the uniform field position is used to make up this head, designed for measurement on magnetic recording tape, magnetic steels, etc.

(b) 0 to 150 oersted. The head consists of a Helmholtz coil arrangement, for the examination of plane film memory stores.

(c) 0 to 10 oersted. The head uses a single turn drive winding and a single turn pick-up winding, suitable for measurements on toroidal films.

The equipment is used with a standard oscilloscope (e.g. Cossor type 1049).

EE 31 772 *for further details*

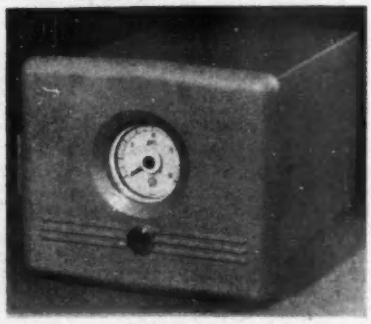
W. G. PYE & CO. LTD

Granta Works, Cambridge

INDUSTRIAL pH AMPLIFIER

(Illustrated below)

This instrument utilizes a circuit which is essentially a carrier type d.c. amplifier employing a capacitor modulator, carrier amplifier and a phase sensitive demodulator with a high degree of overall negative feedback. This provides a high degree of stability with almost perfect linearity, while normal supply voltage variations give practically no change is zero setting or sensitivity. Owing to the absence of any input current, it is possible to use the most robust glass electrodes since their very high resistance does not introduce any errors in linearity; this is particularly important when operating over a wide range of temperature. The sensitivity is high (100μA/pH) and therefore several external recorders, indicators, controllers and alarm systems can be operated from the same amplifier and, if necessary, they may be situated some distance away.



The instrument provides complete automatic temperature compensation over the range 0 to 100°C and the standard instrument covers measurements between 2 and 12pH.

EE 31 773 *for further details*

A.C. Bridge Amplifiers and Power Unit

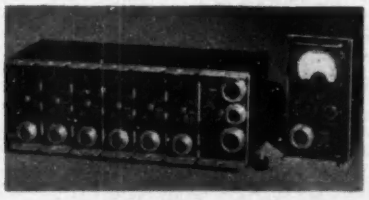
(Illustrated below)

This equipment is manufactured to the design of R.A.E. Farnborough. It is fully transistorized and employs printed circuits for compactness and ease of production.

Amplifier type IT 1-13-51 is designed for use with push-pull inductance accelerometers and contains the integration circuits required to record 'displacement' by means of oscillographs, galvanometers or frequency modulation tape recorders over the range of 5 to 100c/s.

Amplifier type IT 1-12-51 is designed for use with resistance strain gauges and contains bridge resistors of extreme stability and matched temperature coefficients. This unit also records 'displacement' by means of oscillographs, galvanometers or frequency modulation tape recorders and it covers a frequency range from zero to approximately 1kc/s.

Power unit type IT 1-13-52 contains the power supply circuits for six of either or both of the above types of amplifier and also provides the carrier frequency signal for excitation of the transducer bridges and demodulation of



the six amplifiers. The carrier frequency is either 2kc/s or 3kc/s, the changeover being affected by means of an internal link.

The units operate from a normal aircraft d.c. supply of 27 to 29V. Meter units for both type of amplifier are also available.

EE 31 774 *for further details*

RACAL INSTRUMENTS LTD

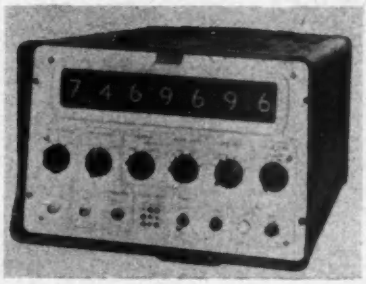
Western Road, Bracknell, Berkshire

Digital Frequency Meter

(Illustrated above right)

The SA.505 combines the latest transistor techniques in a compact, self-contained instrument and is suited to all laboratory applications in the fields of frequency, period and time interval measurement.

A seven digit in-line projection display is incorporated which is arranged to display continuously. The facilities include direct frequency measurement of sine wave and pulse signals in the range 0 to



10Mc/s, time interval measurement between two successive positive going pulses in the range 0·1μsec to 10^4sec. Period measurement can also be made over 1, 10 and 100 cycles of the unknown frequency with an accuracy of up to 1 part in 10^6.

The accuracy of frequency measurement ±1 count ± the stability of the internal crystal which is 1 part in 10^7, provision is made for operation from an external frequency standard of 100kc/s or 1Mc/s.

Digital output are available from the instrument in the form of relay contact closures enabling a remote read-out to be operated directly or alternatively a printed digital record may be obtained by employing the 10 way serializer type SA.138 operating an Addo-X printing machine.

EE 31 775 *for further details*

W. H. SANDERS (ELECTRONICS) LTD

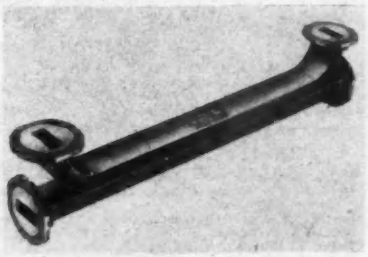
Gunnels Wood Road, Stevenage, Hertfordshire

Multi-Hole Directional Couplers

(Illustrated below)

These multi-hole directional couplers are available in sizes 12, 14, 15, 16, 18 and 22 waveguide and cover the complete band from 3·95Gc/s to 40Gc/s.

These couplers employ circular holes as coupling elements between the broad walls of the two waveguides, arranged as a Tschebyeshef array. The chief advantage of this lies in the fact that the directivity can be made extremely broadband without deterioration near the band extremities, as in the case of the binomial array. It is therefore possible to design the couplers to have greater than 40dB directivity over the complete frequency range with coupling frequency sensitivity of ±0·5db and accuracy of mean coupling of ±0·3dB.



EE 28 776 *for further details*

STANDARD TELEPHONES & CABLES LTD

Connaught House, Aldwych, London, W.C.2

Epitaxial Transistors

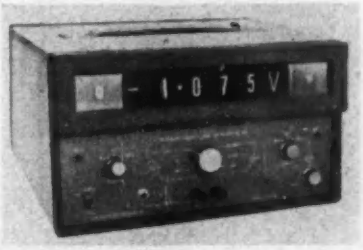
Epitaxy is a process in which a layer of semiconductor material is built up by germanium di-iodide, at a high temperature on to a seed crystal at a lower temperature. The deposited material has the same crystal orientation as the seed.

In most diffused transistors the material that forms the collector region has o have a high resistivity in order to achieve a high collector breakdown voltage. A limit has hitherto been imposed on the thinness of the collector region by the mechanical problems of handling transistors made from very thin slices of material. Thus a high breakdown voltage has not been compatible with good bottoming characteristics (ie., low collector series resistance).

In epitaxial transistors a very thin layer of high resistivity material is deposited on one side of a slice of low resistivity material. The transistor is then made by solid-state diffusion into the high resistivity material using standard techniques. The low-resistivity (seed) material acts simply as a 'backing' for the transistor and gives it mechanical strength.

The resultant transistor has much improved bottoming characteristics and the use of epitaxy gives greater device design flexibility because the interdependence of some of the transistor's parameters is much reduced. This can result in fast switching times and lower output capacitance.

EE 31 777 *for further details*



VENNER ELECTRONICS LTD

Kingston By-Pass, New Malden, Surrey

Digital Volt-Ohm Meter

(Illustrated above)

This instrument is capable of measuring voltages from 1mV to 1·1kV a.c. or d.c. and resistance to 1·1MΩ.

The results are clearly displayed by four new type in-line projection indicators, with automatic sign indication, and may be recorded by direct coupling to a Venner printer and/or a reperforator control unit.

The instrument performs many other digitization functions, and is suitable for operation as a single instrument, or for inclusion in any data logging system.

It employs no stepping switches or relays, and consists of transistorized plug-in stages. It provides steady readings with fluctuating input, and is simple to operate.

EE 31 778 *for further details*

Meetings this Month

BRITISH INSTITUTION OF RADIO ENGINEERS

London Meetings
Date: 16 March. Time: 5.30 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Lecture: Transistorized Tape Recorders.
By: S. Welldon.
Date: 22 March. Time: 5.30 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Lecture: The Future of High Speed Storage Systems.
Date: 27 March. Time: 3 p.m.
Held at: The Post Graduate Medical School, University of London, Hammersmith, W.12.
Lecture: Symposium on Electronic Instruments for Cardiac Surgery.

Southern Section
Date: 21 March. Time: 7 p.m.
Held at: Farnborough Technical College.
Lecture: The Design of a Long Range Single Sideband Airborne Equipment.
By: P. D. Adams and T. E. Wynne.

South Midlands Section
Date: 23 March. Time: 7 p.m.
Held at: The Winter Gardens, Malvern.
Lecture: Magnetic Film Storage.
By: A. C. Moore.

South Western Section
Date: 15 March. Time: 7 p.m.
Held at: School of Management Studies, Bristol.
Lecture: Airborne Servo System for Throttle Control.
By: D. W. Thomasson.

West Midlands Section
Date: 22 March. Time: 6.15 p.m.
Held at: Birmingham University.
Lecture: A Pulse Time Multiplex System for Stereophonic Broadcasting.
By: G. D. Browne.

North Western Section
Date: 2 March. Time: 7 p.m.
Held at: Reynolds Hall, College of Technology, Manchester 1.
Lecture: Some Typical Uses for E.D.P. Systems.
By: C. W. Blaxter.

North Eastern Section
Date: 8 March. Time: 6 p.m.
Held at: Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle-upon-Tyne.
Lecture: AM/FM Transistor Receivers.
By: H. A. Heins.

Merseyside Section
Date: 15 March. Time: 7 p.m.
Held at: Adelphi Hotel, Liverpool.
Lecture: Flight Simulators.
By: D. J. Mauchel and R. Marvyn.

THE INSTITUTION OF ELECTRICAL ENGINEERS

All meetings will be held at Savoy Place, London, W.C.2, unless otherwise stated.

I.E.E. and R.Ae.S. London Joint Group
Date: 1 March. Time: 6 p.m.
Held at: The Royal Aeronautical Society, 4 Hamilton Place, W.1.
Lecture: The Training of Electrical and Electronic Engineers for the Aircraft Industry.
By: G. S. Bosworth.

Ordinary Meeting
Date: 2 March. Time: 5.30 p.m.
Lecture: The Place of Formal Study in the Post-Graduate Training of an Electrical Engineer.
By: N. N. Hancock and P. L. Taylor.

Medical Electronics Discussion Group
Date: 3 March. Time: 6 p.m.
Lecture: The Clinical Value of E.E.G. Recording and Present Trends in General Purpose E.E.G. Recorders.
By: H. B. Morton and H. R. A. Townsend.

Electronics and Communications Section
Date: 6 March. Time: 5.30 p.m.
Lecture: An Investigation of the Usefulness of Back-Scatter Sounding in the Operation of H.F. Broadcasting Services.
By: E. D. R. Shearman.

Measurement and Control Section
Date: 7 March. Time: 5.30 p.m.
Lecture: The Automatic Control of Machines for Assembling Mechanical Components.
By: A. V. Hemingway and R. L. Dressler.
Date: 21 March. Time: 5.30 p.m.
Lecture: Self-Adaptive Control Systems.
By: J. H. Wescott, J. L. Souce, P. E. W. Grinsted and P. H. Hammond.
Date: 15 March. Time: 5.30 p.m.
Held at: Savoy Place.
Lecture: Magneto-Hydrodynamic Generation of Electricity.
By: P. L. Davies and D. J. Harris.

Informal Meeting
Date: 13 March. Time: 5.30 p.m.
Lecture: Town Planning and Electrical Requirements.
By: L. H. Welch.

Education Discussion Circle
Date: 14 March. Time: 6 p.m.
Lecture: New Routes into National Certificate and Technician Courses.
By: H. W. French.

Utilization Section
Date: 16 March. Time: 5.30 p.m.
Lecture: A Dynamic Model for Studying the Behaviour of the Overhead Equipment used in Electric Railway Traction.
By: D. S. Farr, H. C. Hall and A. L. Williams.

Electronics and Supply Sections
Date: 22 March. Time: 5.30 p.m.
Lecture: The Engineering Aspects of Plasma Physics.
By: R. Carruthers and D. L. Smart.

South Midland Centre
Date: 20 March. Time: 7.30 p.m.
Held at: Winter Gardens, Gt. Malvern.
Lecture: Radiocommunications by Means of Satellites.
By: A. W. Lines.

Southern Centre
Date: 14 March. Time: 6.30 p.m.
Held at: University, Southampton.
Lecture: Analogue to Digital Converter Techniques and their Applications.
By: K. L. Smith.
Date: 21 March. Time: 6.15 p.m.
Held at: Farnborough Technical College.
Lecture: Recent Research in Thermionics.
By: G. H. Metson and Miss E. Macartney.
Date: 22 March. Time: 6.30 p.m.
Held at: Grand Hotel, Bournemouth.
Lecture: Radiocommunication in the Power Industry.
By: E. H. Cox and R. E. Martin.
Date: 23 March. Time: 6.30 p.m.
Held at: South Dorset Technical College, Weymouth.
Lecture: High-Voltage Engineering.
By: E. L. White.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Date: 1 March. Time: 5 p.m.
Held at: Conference Room, Waterloo Bridge House, S.E.1.
Lecture: The Study of Men at Work.
By: D. C. Blair and S. T. E. Kent.

THE PLASTICS INSTITUTE

Date: 7 March. Time: 6.30 p.m.
Held at: Wellcome Building, Euston Road, London, N.W.1.
Lecture: Polyurethanes—Development and Uses.
By: H. A. Hampton and R. Hurd.

THE SOCIETY OF INSTRUMENT TECHNOLOGY

Date: 15 March. Time: 6.30 p.m.
Held at: Manson House, 26 Portland Place, London, W.1.
Lecture: Symposium on Burst Slug Detection in Nuclear Power Stations. Initial Experience on the Use of a Digital Computer for Burst Slug Detection.
By: J. L. W. Churchill and R. S. Hopkins.
Lecture: Burst Slug Detection Data Display at Bradwell.
By: J. O. Joss.
Date: 28 March. Time: 5 p.m.
Held at: Manson House, 26 Portland Place, London, W.1.
Lecture: Automatic Optimization.
By: Dr. P. E. W. Grensted and O. L. R. Jacobs.
Date: 28 March. Time: 7 p.m.
Lecture: The Development of an Optimizing Controller.
By: P. F. Sutherby.

THE TELEVISION SOCIETY

Date: 10 March. Time: 7 p.m.
Held at: The Research Laboratories, E.M.I. Ltd, Hayes, Middlesex.
Lecture: Colour Television Camera Problems.
By: I. J. P. James.
Date: 23 March. Time: 7 p.m.
Held at: The Marine Station, Millport.
Lecture: Underwater Television in Marine Biology.
By: Dr. H. Barnes.

PUBLICATIONS RECEIVED

F.B.I. REGISTER OF BRITISH MANUFACTURERS—1961 is the 33rd Edition. The Register contains lists of the products and services of nearly 8 000 member firms under more than 5 400 alphabetical headings. In addition to a Classified Buyers' Guide there are seven other sections in the Register, giving addresses of Companies and Firms and information about Trade Associations, proprietary names, trade marks, etc. The Register is published for the Federation of British Industries by Kelly's Directories and Iliffe and Sons Ltd, price 50s. post free.

GENERAL RADIO HANDBOOK OF NOISE MEASUREMENT is an illustrated 100-page book covering the measurement of noise and vibration, and describing equipment requirements, procedures and the interpretation of results. Copies of the handbook are available at $1.00, post paid from the General Radio Company, West Concord, Massachusetts, U.S.A.

JOHNSON MATTHEY & CO. LIMITED have produced a new version of their publication 1302, 'Electrical Contacts'. This booklet is intended to help designers of electrical and electronic equipment to select contact materials and to determine optimum contact dimensions and operating force. It also serves as a guide to buyers on the availability of materials and gives information on the stocks carried in the JMC Standard Contact ranges. Copies of the booklet are freely available on request to the Company's head office at 73-83 Hatton Garden, E.C.1.

CONTACT ENGINEERING is the title of a brochure describing the contact engineering facilities provided by Negretti and Zambra Ltd, 122 Regent Street, London, W.1, from whom copies may be requested.

UNBRAKO SOCKET SCREW CO. LTD. have recently published a range of technical leaflets which they state will be of interest to engineers and technicians in the aerospace and allied industries. The set of leaflets is available free on request from the Company's Advanced Design Division, P.O. Box 38, Burnaby Road, Coventry.

AUTOMATION by H. A. Thomas of Unilever Ltd is an illustrated record of the Faraday Lectures 1958/9, given at the invitation of the Institution of Electrical Engineers. Copies of the book are available on request to the Information Division, Unilever Ltd, Unilever House, E.C.4.

CAREERS IN THE SCIENTIFIC INSTRUMENT INDUSTRY gives an illustrated summary of what a new entrant into the industry can expect to find and what his work and training may be like. The booklet is published by The Scientific Instrument Manufacturers' Association of Gt. Britain, 20 Queen Anne Street, W.1.

LINE FAULT LOCATOR is a leaflet describing this instrument as demonstrated at the Glasgow Power Station by Ferranti Ltd of Hollinwood, Lancs. The instrument is known as an a.c. line fault locator, which operates on the radar principle of pulse reflection occurring from any discontinuity which may be due to a flashover or to ice build-up on the line.

STANDARD RANGE OF SELENIUM RECTIFIERS bulletin SR-2006 published by the International Rectifiers Co. (Great Britain) Ltd describes the range of stock selenium rectifiers from which this Company can give immediate delivery. The rectifiers are designed to meet the most commonly required outputs, i.e. h.t. supplies for electronic equipment, radio and television, also l.t. outputs for battery charging and transistor supplies. Further details are available from the General Manager, Hurst Green, Oxted, Surrey.

A LOW ENERGY BETA PROBE by K. E. G. Perry and R. A. Bishop. This probe (A.E.R.E. type 1667) has been designed for the detection and measurement of low energy beta radiation. It has an efficiency of 14 per cent for C14 and 28 per cent for Sr.90. The detecting area is over a 5in diameter and the design is suitable for use with most standard ratemeters. A copy of this booklet is available from H.M. Stationery Office, price 3s.

SOUND EQUIPMENT is a pamphlet showing the range of standard public address and sound equipment now being distributed by Audix B.B. Ltd, Bentfield End, Stansted, Essex, from whom a copy of this pamphlet is available together with the price list.

EE 31 120 *for further details*

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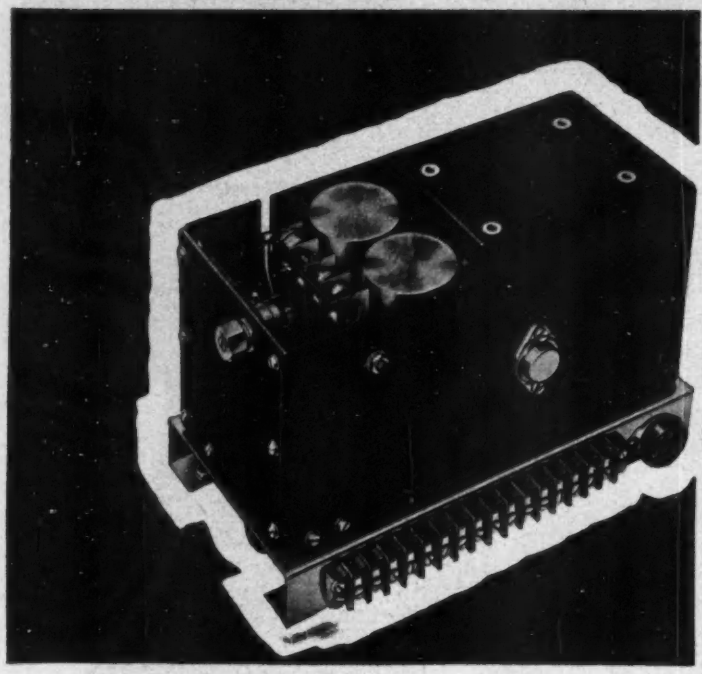
EE 31 121 *for further details*

CHOOSE BELIX



CHOOSE BELIX TRANSISTOR POWER SUB-UNITS

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TYPE No.	TSS 51	TSS 62	TSS 63	TSS 300	TSS 04	TSS 14	TSS 24	TSS 34	TSS 44	TSS 241	TSS 114	TSS 104	TSS 94	TSS 84	TSS 74	TSS 121	TSS 122	TSS 123	TSS 124	TSS 125	TSS 51	TSS 52	TSS 53	TSS 54	TSS 55
OUTPUT *d.c. volts:*	0-12	0-12	0-12	0-24	0-6	6-14	12-20	16-24	20-30	0-24	0-6	6 14	12-20	16-24	22-30	0-6	6-12	12-20	16-24	20-30	0-6	6-12	12-20	16-24	20-30
OUTPUT *amps (max.):*	0·1	0·3	0·5	1·0	1·0	1·0	1·0	1·0	1·0	1·0	2·0	2·0	2·0	2·0	2·0	6·0	6·0	6·0	6·0	6·0	10·0	10·0	10·0	10·0	10·0
STABILITY RATIO *(7% mains)*	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1	1000 :1
SOURCE RESISTANCE Ω *less than:*	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0 01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01
A.C. IMPEDANCE Ω *(max.) to 200 kc/s:*	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15
RIPPLE *(pk-pk) mV less than:*	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0

* *Provides two independent outputs.* ⊙ *Available as plug-in or wire-in sub-unit. TSS 61, 62, 63 are continuously variable; all other units have coarse step plus fine adjust facility.*

belix

Le Matériel Électronique au Salon de la PHYSICAL SOCIETY

Une description, basée sur des renseignements fournis par les fabricants, d'un choix de matériels électroniques exposés au 45ème Salon de la Physical Society, tenu à Londres du 16 au 20 janvier 1961.

(Traduction des pages 184 à 189)

ADVANCE COMPONENTS LTD

Roebuck Road, Hainault, Ilford, Essex

SPECTROMÈTRE ACOUSTIQUE

(Illustration à la page 184)

Le spectromètre acoustique Advance est un instrument précis, stable et léger, ayant sa propre alimentation par batterie et étant donc entièrement autonome. Il est d'un modèle très perfectionné et convient aux problèmes et à l'analyse de la mesure acoustique. Grâce à ses filtres de bande d'octaves incorporés, on peut analyser rapidement les bruits à spectres complexes. Il peut également être utilisé avec un capteur de vibrations approprié pour l'analyse des vibrations dans la gamme des basses fréquences. Le SPM.1 se prête particulièrement bien à l'analyse des bruits d'avions, de véhicules, de machines, ainsi que pour l'analyse des bruits de bureau où le niveau des parasites vocaux constitue un facteur important.

L'instrument se compose d'un tout petit microphone piézoélectrique, d'un amplificateur à six étages stabilisé par une forte contre-réaction de 8 filtres passe-bande pouvant être mis en circuit au choix, et d'un appareil de mesure à cadre mobile avec échelle de décibels. Il comporte également un atténuateur incorporé à 5 plots de 10dB couvrant une gamme de 30 à 80dB, ainsi qu'un atténuateur complémentaire à 3 plots de 20dB couvrant une gamme de 0 à 60dB. La gamme complète du spectromètre, y compris l'échelle de l'appareil de lecture, est de 20dB à 150dB, en fonction du niveau de référence de la pression sonore normale de 2×10^{-4} μb ($= 2 \times 10^5$ N/m²). Des sons dans la gamme de fréquences de 20 Hz à 10 kHz peuvent être mesurés et analysés en bandes d'octaves à l'aide du filtre incorporé. L'état des batteries incorporées peut être vérifié au moyen de l'appareil de mesure à cadre mobile.

EE 31 751 *pour plus amples renseignements*

AIRMEC LTD

High Wycombe, Buckinghamshire

OSCILLOSCOPE À ACTION RAPIDE

(Illustration à la page 184)

L'oscilloscope type 294 est un instrument de laboratoire d'une grande souplesse d'emploi, sa gamme étendue de vitesses de balayage ainsi que la réponse de fréquence étendue (du courant continu à 50 MHz) et le temps de montée rapide de l'amplificateur Y, le rendent très indiqué pour les applications à impulsions à grande vitesse. Il est aussi des plus utiles pour les mesures générales de laboratoire, en raison de l'étalonnage précis des bases de temps et de l'amplificateur de déviation, de ses marqueurs de temps et de tension, et de ses dispositifs perfectionnés de déclenchement et de retardement de balayage.

Des sorties d'impulsions synchronisées avec les bases de temps intérieures facilitent le fonctionnement en liaison avec tout matériel électronique compliqué. Le balayage monocourse, l'éclairage variable par la tranche du quadrillage et les potentiels d'accélérateur de post-déviation alternatif commuté, facilitent la photographie de la trace. Des indicateurs éclairés de position de faisceau et des commandes à codes de couleurs logiquement disposées garantissent la sécurité et la simplicité du fonctionnement.

L'appareil complet, réalisé par une société française fort connue et fabriqué sous licence par Airmec se compose d'un ensemble d'affichage monté en diagonale, pour faciliter l'indication, sur un trolley en acier tubulaire muni de roulettes et portant le bloc d'alimentation à sa base. Le refroidissement forcé par air filtré et l'utilisation de pièces de haute qualité contribuent à la sûreté maximale de son fonctionnement.

EE 31 752 *pour plus amples renseignements*

CAWKELL RESEARCH & ELECTRONICS LTD

Scotts Road, Southall, Middlesex

OSCILLOSCOPE À MÉMOIRE DE TÉLÉVISION

(Illustration à la page 184)

Le "Tele-Remscope" est un nouveau genre de contrôleur d'images pour systèmes de télévision à circuit fermé. Il se caractérise principalement par le fait que l'image peut être "saisie" à n'importe quel moment par simple pression d'un bouton ou actionnement d'un interrupteur.

Le "Tele-Remscope" fonctionne sur 405 ou 625 lignes, 50 champs/sec ou 525 lignes, 60 champs/sec, et nécessite une entrée vidéo positive de 15V. N'importe quel nombre de champs de 1 à 4 peut être enregistré et affiché pendant une durée de temps allant jusqu'à 15 minutes sur la face d'un tube de mémoire English Electric E.702. L'écran a 10cm de diamètre et produit une fluorescence jaune/vert (P20).

EE 31 753 *pour plus amples renseignements*

DAWE INSTRUMENTS LTD

99-101 Uxbridge Road, Ealing, London, W.5

GÉNÉRATEUR DE BRUITS ULTRA-BASSES FRÉQUENCES

(Illustration à la page 184)

Le générateur de bruits ultra-basses fréquences type 418 fournit des bruits d'origine électrique avec un spectre de fréquences uniforme à ±0,5dB près, de 0 à 200 Hz.

La source de bruit dans l'instrument est constituée par un thyratron produisant des bruits d'origine électrique de spectre uniforme dans la gamme des basses fréquences. Le débit de bruits passe d'un filtre à bande relativement large, centré à 2 kHz, à un circuit de modulateur ou il est mélangé à la sortie d'un oscillateur local à fréquence fixe fonctionnant à 2 kHz.

La sortie du modulateur passe par un

filtre passe-bas afin d'éliminer les produits de la modulation à haute fréquence. Le signal, de basse fréquence est amplifié dans un amplificateur de tension continue, avec une sortie de cathode asservie à faible impédance attaquant les bornes de sortie et un appareil indicateur. Ce dernier est étalonné pour pouvoir lire les valeurs efficaces de bruits erratiques. Le niveau de sortie est à réglage continu par un potentiomètre variant le gain de l'amplificateur. Une grande stabilité dans le niveau de sortie fixe et une dérive réduite de courant continu sont obtenues par l'utilisation de sources d'alimentation stabilisées de basse et haute tension et une réaction négative élevée dans l'amplificateur. La gamme dynamique étendue de l'amplificateur assure la distribution d'amplitude aléatoire avec écrêtage insignifiant de la forme d'onde jusqu'à la pleine sortie nominale. Le circuit a été réalisé à partir d'un projet original de D. A. Bell et A. M. Rosie, de l'Université de Birmingham.

EE 31 754 *pour plus amples renseignements*

OSCILLATEUR AUTOMATIQUE BASSE-FRÉQUENCE

(Illustration à la page 185)

L'oscillateur en dents de scie automatique b.f. Type 444 répond à la demande d'un oscillateur accordé résistance-capacité à faible distorsion et gamme unique de 5 Hz à 5 kHz. Cet oscillateur fournit une sortie de tension constante et l'étalonnage de l'échelle de fréquences est intégralement logarithmique. La commande de fréquence de balayage est actionnée par moteur autonome prévu pour donner différentes vitesses de balayage entre n'importe quelles limites voulues de fréquence. La direction du balayage peut être réglée pour l'inversion automatique aux fréquences de limite. En variante, elle peut être arrêtée à n'importe quel moment par télécommande.

Le circuit consiste essentiellement d'un pont de contrôle de fréquence qui alimente un amplificateur push-pull équilibré avec sortie de cathode asservie.

Le réseau de contrôle de fréquence consiste en une forme modifiée de pont de Wien dont les bras résistifs ont été remplacés par des réseaux complexes de résistance-capacité. Ces derniers étendent la gamme de fréquences de déphasage constant dans un rapport de 1000:1 avec un rapport de capacité de 10,1 pour le condensateur d'accord. Le condensateur d'accord a un arbre de rotor pouvant tourner de manière continue et spécialement prévu pour assurer un étalonnage d'échelle intégralement logarithmique.

Une commande par moteur et une boîte de vitesse assurent six vitesses de balayage allant de 0,2 à 10 octaves par minute. Des disjoncteurs de sécurité réglables permettent le balayage de fréquence dans n'importe quelle partie de la gamme.

Le balayage peut aussi être contrôlé au moyen de l'ensemble de télécommande type 444/1. La fréquence peut être balayée vers l'avant ou inversée, ou le balayage peut être arrêté à n'importe quel moment. Alternativement, l'échelle de fréquences peut être réglée manuellement à n'importe quelle fréquence voulue.

Le signal du pont est introduit dans l'amplificateur push-pull équilibré, ce dernier étant relié directement à l'étage à charge cathodique. Une contreréaction est appliquée à partir des cathodes de l'étage de sortie aux grilles des lampes d'amplificateur. Un élément de résistance thermiquement sensible est incorporé dans les bras résistifs du pont afin de stabiliser l'amplitude d'oscillation à un niveau compris dans la gamme linéaire de l'amplificateur équilibré. Grâce à ce dispositif, ainsi qu'à la contreréaction élevée aux fréquences harmoniques, une bonne stabilité et une faible distorsion de l'onde sinusoïdale de sortie sont assurées. Dans la boucle entière de contreréaction, un volume contrôlé de réaction positive est appliqué à l'étage de sortie uniquement afin de réduire virtuellement à zero son impédance de sortie. Les bornes de sortie son alimentées à partir d'un potentiomètre accouplé aux sorties de cathodes asservies.

Des sorties push-pull allant jusqu'à 12 V dans 10 kΩ sont fournies aux bornes de sortie. Les niveaux de sortie sont à variation continue du maximum à zéro.

EE 31 755 *pour plus amples renseignements*

DYNATRON RADIO LTD

Maidenhead, Berkshire

APPAREIL D'ESSAI NUCLÉAIRE

L'appareil d'essai type N107 comprend un double générateur d'impulsions et un oscilloscope de mesure combinés, et il est prévu pour l'entretien des instruments communément employés dans le domaine nucléaire comme, par exemple, les amplificateurs d'impulsions, discriminateurs, échelles de comptage, intensimètres et analyseurs d'amplitude des impulsions. Un maître-multivibrateur contrôle la fréquence de répétition des impulsions de la paire d'impulsions.

Le signal principal de fréquence de répétition des impulsions déclenche (1) un générateur de largeur d'impulsions et un étage de dents de scie (2). L'impulsion fixe engendrée par (1) est limitée en amplitude puis injectée à une paire de contrôle d'amplitude, permettant de choisir des impulsions à direction négative ou positive. Une double cathode asservie alimente soit la borne de sortie de l'appareil d'essai soit un autre atténuateur. La dent de scie provoquée par (2) fournit un balayage X à l'amplificateur X de l'oscilloscope, et attaque aussi une porte d'amplitude. Lorsque la dent de scie franchit le niveau de la porte (réglé par commande de séparation d'impulsions), un générateur de largeur d'impulsions, semblable à (1), produit l'impulsion mobile (seconde), qui est traitée de la même manière que la première impulsion (fixe), c'est à dire qu'elle est limitée, injectée à une paire de contrôle d'amplitude, puis aux cathodes asservies de sortie. L'action complète du générateur d'impulsions fournit une paire d'impulsions, à direction positive ou négative, pouvant être contrôlées indépendamment en largeur et en amplitude, avec séparation variable entre elles. On peut mettre hors circuit soit l'impulsion fixe soit la seconde impulsion variable, selon les besoins.

L'appareil est complété par un amplificateur Y, commuté de manière à pouvoir obtenir une réponse à large bande sur gain moyen, ou un gain éleoré dans une largeur de bande réduite. L'amplitude est mesurée par système a contrôleur de dérive Y.

EE 31 756 *pour plus amples renseignements*

E.M.I. ELECTRONICS LTD

Hayes, Middlesex

AMPLIFICATEUR À GRAND GAIN

L'amplificateur à grand gain type 7/5 fait partie d'une série de sous-ensembles interchangeables produits pour être utilisés avec l'oscilloscope WM.16.

Il offre les mêmes possibilités que l'amplificateur à large bande 7/1 et, en outre, le gain peut être accru par un facteur de 10, dans des conditions de couplage au courant alternatif, afin de donner une sensibilité maxima de 5 mV/cm pour une largeur de band réduite.

L'amplificateur à grand gain s'adapte au panneau frontal de l'oscilloscope W.M.16 et toutes les tensions nécessaires proviennent de l'oscilloscope principal.

Un sélecteur d'entrée à trois positions fournit les combinaisons suivantes de sensibilités de largeur de bande:

Temps de montée c.c. 10 mμsec; largeur de bande c.c. à 40 MHz; sensibilité 50 mV/cm à 20 V/cm en neuf gammes étalonées et commutées.

Temps de montée c.a. 10mμsec; largeur de bande 3 Hz à 40 Hz; sensibilité 50 mV/sec à 20 V/cm.

C.A. × 10: Temps de montée 16 mμsec; sensibilité 5 mV/cm à 2 V/cm en neuf gammes étalonnées et commutées; constante de temps d'entrée 0,05 sec.

EE 31 757 *pour plus amples renseignements*

AMPLIFICATEUR DIFFÉRENTIEL

(Illustration à la page 185)

L'amplificateur différentiel type 7/6 est un élément interchangeable complémentaire pour l'oscilloscope W.M.16 et il permet d'observer deux entrées séparément ou différentiellement, soit couplées sur courant alternatif soit sur courant continu. Les mesures d'amplitude peuvent se faire par cadran ou quadrillage, sauf lorsque l'entrée B est employée sur courant continu. Dans cette dernière position la mesure se fait par quadrillage.

Chaque voie a des atténuateurs à part permettant une variation de sensibilité de 50 mV/cm à 20 V/cm en neuf gammes. Une commande de gain précis assure le réglage continu entre positions d'atténuateurs.

La largeur de bande va de 25 MHz ou

4 Hz à 25 MHz et le temps de montée est de 16 mμsec. Le rapport de rejet est supérieur à 100:1 dans la bande passante sur couplage c.c. et supérieur à 100:1 de 10 Hz à 25 MHz sur couplage c.a. pour un gain total.

EE 31 758 *pour plus amples renseignements*

ELECTRONIC TUBES LTD

Kingsmead Works, High Wycombe, Buckinghamshire

SUBSTANCES LUMINESCENTES D'EMMAGASINAGE

Au cours d'une démonstration on a pu voir les propriétés d'un tube cathodique normal muni d'une nouvelle matière d'écran.

Au moment où l'écran est excité pour la première fois, il se produit une fluorescence bleue semblable à celle d'une substance luminescente normale à deux couches et à longue persistance. Ceci est suivi d'une persistance de durée comparable à celle obtenue avec la substance luminescente à deux couches, sauf que la phosphorescence de cet écran est de couleur verte.

Même après la disparition totale de la phosphorescence, d'autres indications peuvent encore être obtenues avec cet écran. Une certaine quantité d'énergie reste deposée dans la substance luminescente à l'endroit où elle a été excitée, et elle peut être déclenchée au moyen d'un éclairage infrarouge. L'intensité visuelle de l'image emmagasinée dépend de l'intensité de la source infrarouge. Ceci s'applique également à la durée de vision avant que l'image soit effacée. Etant donné qu'une quantité spécifique d'énergie peut être déclenchée, en augmentant l'intensité de la source infrarouge on décroît la durée de vision et vice versa.

Un avantage complémentaire est que l'image emmagasinée n'a pas besoin d'être observée jusqu'à son extinction, en une seule opération. Elle peut être observée à plusieurs reprises de courte durée et à quelques minutes d'intervalle.

Avec un dispositif d'emmagasinage tel que celui ci, il va de soi que l'énergie emmagasinée dépend directement de l'energie d'excitation. Vu que le pouvoir d'emmagasinage est relativement faible, son utilisation à de grandes vitesses d'enregistrement est impossible. Il n'est pas recommandé non plus pour l'emploi avec des tubes de faible tension en raison des quantités réduites d'énergie dont il est question.

En principe, la substance luminescente peut être appliquée à n'importe quel tube cathodique fabriqué par Electronic Tubes Ltd mais elle ne sera pas appliquée aux tubes de faible tension par suite de son utilité limitée pour ces derniers.

EE 31 759 *pour plus amples renseignements*

ELLIOTT BROTHERS (LONDON) LTD

Century Works, Lewisham, London, S.E.19

MATÉRIEL DE CONTRÔLE AUTOMATIQUE DE CIRCUITS

(Illustration à la page 186)

Ce matériel a été étudié pour faciliter le contrôle courant de formes de câbles compliquées ou de dispositifs analogues, de façon entièrement automatique en préréglant le processus de contrôle et d'essai dans la machine.

Le modèle dont ou a pu voir une démonstration peut effectuer les tests suivants avec un nombre d'extrémités pouvant aller jusqu'à 600. Chaque extrémité est contrôlée par rapport à toutes les autres:

(1) Résistance: 0 à 1000 ohms.
(2) Continuité non supérieure à 0,5 ohms.
(3) Isolement entre lignes supérieur à 20 Mégohms.
(4) Isolement à la masse supérieur à 20 Mégohms.

N'importe lequel de ces essais peut être effectué pour une paire particulière d'extrémités par un programme prédéterminé. Les instructions sont "rédigées" sur bande magnétique de 2,5 cm, en accord avec un tableau de câbles ou d'extrémités s'appliquant au matériel soumis à l'essai. Ce matériel est relié à l'appareil de contrôle automatique de circuits en séquence numérique normale coïncidant avec le tableau d'extrémités et le numérotage de programme.

Le nombre de combinaisons possibles avec 600 extrémités est de 180.300. Une bande magnétique de 305cm de longueur suffit pour recevoir toutes les données de programme possibles.

Un perfecctionnement ultérieur permettra à la machine de vérifier presque n'importe quel assemblage électronique/électrique avec un minimum de travail. Un enregistreur automatique de défauts, sous forme d'imprimeur codé, est en cours d'étude.

EE 31 760 *pour plus amples renseignements*

RECEPTEUR DE FRÉQUENCE STANDARD

Cet instrument est prévu pour recevoir l'émission standard de 200 kHz de Droitwich, qui est exacte dans une mesure d'environ 20 parties de 10^9 et présente l'avantage complémentaire d'être comparée presque quotidiennement, à 10H33 (heure moyenne de Greenwich), avec le résonateur au césium du Laboratoire National de Physique. Le débit n'est nullement affecté par la modulation.

Le contrôleur de fréquence standard produit les fréquences suivantes à partir d'une source d'impédance élevée ondes sinusoïdales de 5V crête-à-crête à 50, 100, 200 et 400 Hz, et 20 et 200 kHz; ondes carrées de 2V crête-à-crête à 50, 100, 200 et 400 Hz.

D'autres basses fréquences multiples peuvent être fournies sur demande, sauf dans le cas des débits de 200kHz et 20 kHz.

Deux amplificateurs de gain variable, pouvant être commutés sur n'importe laquelle des sources be basse fréquence, permettent d'entraîner d'autres appareils d'énergie. Ce débit va jusqu'à 20 volts efficaces. Un haut-parleur de contrôle est également inclus.

EE 31 761 *pour plus amples renseignements*

AMPLIFICATEUR INDICATEUR DE RAPPORT

(Illustration à la page 186)

Il s'agit ici d'un amplificateur sélectif qui contrôle le gain au moyen d'un potentiel électrique. Cet amplificateur est suivi d'un redresseur en pont et d'un appareil de mesure indicateur.

Au moyen d'un circuit à interrupteur extérieur, la sortie redressée peut être renvoyée à travers un amplificateur à courant continu pour contrôler le gain du système. L'indication de l'appareil de mesure sera constante à 1% près pour une gamme de tensions d'entrée de plus de 50 dB lorsque l'interrupteur est fermé. Si l'interrupteur est ensuite ouvert, le gain de l'amplificateur sera maintenu sensiblement constant pendant une période de temps considérable, au moyen d'un circuit ayant une constante de temps de l'ordre d'une demi-heure. Tout changement dans le niveau du signal d'entrée sera alors enregistré par l'appareil de mesure.

EE 31 762 *pour plus amples renseignements*

ENREGISTREUR À BANDE MULTIVOIES

(Illustration à la page 186)

Cet instrument comporte un système de transport de bande à doubles cabestans et assemblages enrouleurs. Cinq vitesses de bande sont prévues, choisies par commandes à bouton-poussoir, et des fréquences allant jusqu'à 75 kHz peuvent être tenues à 76,2 cm/sec.

Une durée d'enregistrement maxima de près de trois jours peut être réalisée en utilisant seize voies de bande à base mince de 2,54cm à la vitesse de 4,762 cm/sec. L'inversion automatique se fait par le doublage des têtes d'enregistrement et de réenregistrement, cinq têtes interchangeables constituant le nombre de têtes normalement prévues. De bonnes caractéristiques de pleurage et de flottement sont réalisées grâce au mécanisme transporteur de bande et l'entraînement par double cabestan isole toute bande en contact avec les têtes des perturbations pouvant être introduites par les bobines enrouleuses et déroulueses.

Cet appareil est entièrement transistorisé, un usage étendu étant fait des circuits imprimés. Des éléments modulaires à fiches permettent l'enregistrement direct et la modulation de fréquence, toutes les fonctions pouvant être, en outre, commandées à distance. Les principales applications de l'enregistreur sont dans les domaines des engins téléguidés et de l'aéronautique pour l'enregistrement de données télémesurées ainsi que pour les essais de vol.

EE 31 763 *pour plus amples renseignements*

ENGLISH ELECTRIC VALVE CO. LTD

Chelmsford, Essex

RENFORÇATEUR D'IMAGES À GAIN ÉLEVÉ

Ce tube de renforçage d'images à gain élevé se compose d'une cathode photoélectrique d'entrée, de cinq cathodes secondaires et d'un écran fluorescent de sortie, et il est utilisé conjointement avec une solénoïde de focalisation, des systèmes optiques d'entrée et de sortie et des sources d'alimentation.

On focalise l'image devant être renforcée sur la cathode photoélectrique à une des extrémités du tube, cependant que les photoélectrons sont accélérés et focalisés sur la première cathode secondaire à film mince. Des électrons secondaires, cinq ou six pour chaque primaire, sont émis de l'autre côté de la cathode secondaire puis, à leur tour, accélérés et focalisés sur la seconde cathode secondaire. Ce procédé est répété pour chaque cathode secondaire, et les électrons secondaires émis par la cathode secondaire finale sont accélérés sur un écran fluorescent afin de donner une reproduction renforcée de l'image faible originale.

Des tubes ont été fabriqués qui donnent un gain de 100 000 à 200 000 photons, un gain de 7 000 étant fourni par les cinq étages d'une multiplication d'électrons secondaires et le reste provenant du bombardement de l'écran fluorescent secondaire.

Le diamètre utile des cathodes secondaires à film mince est de 2,5 cm. Si nécessaire, les dimensions de l'image peuvent être réduites entre la cathode photoélectrique et la première cathode secondaire, de manière à ce que l'image d'entrée ne soit pas limitée à 2,5 cm. De même, une image agrandie peut être formée sur l'écran au besoin.

EE 31 764 *pour plus amples renseignements*

TUBE CATHODIQUE DE MÉMOIRE BISTABLE

Le tube de mémoire bistable à vision directe E710 représente une nouvelle conception dans la réalisation de ces dispositifs. L'emploi de cette technique comporte beaucoup moins de risques d'endommagement de l'ensemble au cas où un fort courant de faisceau serait appliqué accidentellement, et elle permet donc de simplifier les circuits connexes.

Le nouveau tube peut stocker des informations indéfiniment et autorise, en outre, l'affichage continu ou intermittent de la forme d'onde stockée. Deux ou plusieurs signaux peuvent être stockés et affichés simultanément ou effacés instantanément lorsqu'on n'en a plus besoin.

Le tube E710 a un canon d'écriture, dévié électrostatitiquement et focalisé, qui dépose un relief de charge sur la maille de mémoire, le diamètre du spot étant d'environ 0,025 mm. Un second canon, qui éclaire continûment la maille de mémoire conserve ce signal et l'affiche sur la substance luminescente.

EE 31 765 *pour plus amples renseignements*

MARCONI INSTRUMENTS LTD

St. Albans, Hertfordshire

GÉNÉRATEUR BASSE-FRÉQUENCE

(Illustration à la page 187)

Ce nouveau générateur fournit n'importe laquelle des trois formes d'ondes pouvant être choisies par commutateur, soit: sinusoïdale, carrée ou de rampe, et il est à variation continue dans la gamme de fréquences de 0,0033Hz à 1kHz. Cette gamme de fréquences est couverte en cinq bandes se recouvrant. Un relais incorporé avec contacts à permutation de grande puissance reliés au panneau frontal est actionné par la sortie d'ondes carrées à des fréquences allant jusqu'à 1 Hz. Ceci permet de mettre des dispositifs extérieurs en circuit ou hors circuit en cycle, à la fréquence de fonctionnement.

L'utilité de cet instrument comme chronoscope est considérablement accrue par un dispositif permettant le fonctionnement "d'un seul coup." Le cycle de minutage est déclenché par un commutateur sur le panneau avant, par une impulsion engendrée extérieurement ou par des contacts extérieurs de court-circuit.

Le générateur TF.1382 emploie une méthode inédite pour la production d'ondes sinusoïdales consistant en une synthétisation électronique de la forme d'onde. La forme d'onde de base est une dent de scie ou "rampe" constituant l'une des formes d'onde triangulaire (ne servant pas de sortie). L'onde triangulaire est ensuite façonnée par un circuit à diodes Zéner qui transforme la forme d'onde en onde sinusoïdale. La sortie d'ondes carrées est obtenue de la forme d'onde triangulaire à travers un circuit de commutation bistable.

EE 31 766 *pour plus amples renseignements*

VOLTMÈTRE DONT LE ZÉRO EST HORS DE LA GRADUATION NORMALE

(Illustration à la page 187)

Le voltmètre potentiométrique à comparaison TF 1377 est prévu pour la mesure de tensions absolues allant jusqu'à 500V c.c. et des changements minima de 1mV dans la source soumise à l'essai. Il peut aussi être utilisé comme voltmètre différentiel conventionnel à gamme de ±1mV à ±50V.

Pour le mode de fonctionnement à comparaison ou à zéro hors de la graduation normale, la tension de source est comparée à une alimentation en courant continu contrôlée par potentiomètre, et utilisant l'appareil de mesure à zéro central comme indicateur de zéro. La tension absolue de la source est indiquée par la lecture numérique du potentiomètre, les variations ultérieures de tension étant indiquées par l'appareil de mesure. De faibles changements dans les tensions élevées peuvent donc être mesurées avec une discrimination, une précision et une facilité exceptionnelles, en évitant ainsi l'emploi fastidieux de montages compliqués de batteries extérieures pour rétroactionner la tension stationnaire.

Pour le mode différentiel, le potentiomètre est mis hors de circuit et les petites tensions inconnues sont indiquées directement sur l'appareil de mesure.

L'instrument permet de mesurer rapidement et avec précision une gamme étendue de tensions continues au laboratoire, sur la chaîne de montage ou en service. Son système de mesure incrémentale de précision convient particulièrement à de nombreuses applications telles que les essais de régulation et de stabilité sur sources de tension continue, les mesures de coefficients de température sur semi-conducteurs et résistances, les essais extensométriques directs, l'étalonnage de thermomètres à résistance et de transducteurs piézoélectriques, le réglage de générateurs. Des palpeurs de redressement sont fournis pour étendre son utilité aux mesures de basse et de haute fréquence.

EE 31 767 *pour plus amples renseignements*

MORGAN CRUCIBLE CO. LTD

Battersea Church Road, London, S.W.11

CHARGES DE GUIDE D'ONDES

Ces charges ont été étudiées pour permettre à une station de radar de se maintenir en position d'attente ou d'essai en pleine puissance sans émettre de signal par lequel elle puisse être détectée et sans brouiller d'autres stations. Contrairement aux matières utilisées jusqu'ici à cette fin, le "Termilode," qui est basé sur le carbure de silicium, peut dissiper des kilowatts d'énergie. Les limites de température sont fixées davantage par l'ionisation du gaz dans le guide d'onde que par la matière de la charge. Une température de 1000°C donnera un comportement satisfaisant. Les différentes réalisations qu'on a pu voir (avec des longueurs totales variant de quelques centimètres à quelques mètres) sont prévues pour le refroidissement par air ou par liquides. Une dissipation maxima de 8kW a pu être atteinte par refroidissement à l'eau.

EE 31 768 *pour plus amples renseignements*

MUIRHEAD & CO. LTD

Beckenham, Kent

ANALYSEUR-ENREGISTREUR D'ONDES AUTOMATIQUE

(Illustration à la page 188)

Cet instrument sert à l'analyse automatique et à l'enregistrement graphique de tous les types de signaux de bruits et de vibrations de sources 'directes' ou d'enregistrements sur bandes magnétiques. Il effectue l'analyse d'amplitude/fréquence de signaux stables et l'analyse d'amplitude/fréquence/temps de signaux non-stables (variant en fonction du temps). Il est entièrement automatique dans toute la gamme de fréquences, de 10 Hz à 19 kHz. Pour gagner du temps, on peut lui faire balayer une seule partie de cette gamme de fréquences, si nécessaire. Trois degrés de sélectivité (

d'octave, 5% et 1,5%) peuvent être obtenus et, dans chaque cas, le pourcentage de largeur de bande est constant à toutes les fréquences. La discrimination contre les fréquences indésirables est élevée. L'erreur de fréquence maxima sur le papier d'enregistrement de sortie préimprimé ne dépasse pas 1%. Les signaux d'entrée peuvent être dans la gamme de 10 μV à 300V et lorsque l'atténuateur est réglé pour le fonctionnement automatique, une gamme d'amplitude dynamique allant jusqu'à 70dB peut être contrôlée.

EE 31 769 *pour plus amples renseignements*

NASH & THOMPSON LTD

Hook Rise, Tolworth, Surrey

INSTRUMENT DE LECTURE NUMÉRIQUE

(Illustration à la page 188)

Conçu pour combler le fossé entre le type de présentation du compteur à cadre mobile ordinaire et les voltmètres numériques fort coûteux, le nouveau voltmètre numérique Nashton constitue un compromis efficace et économique. Le commutateur de lecture par pression sur le panneau frontal actionne le pont autoéquilibreur couplé électromécaniquement à l'indicateur. Les changements habituels de lectures numériques ne prennent qu'une seconde ou deux et il faut 10 sec au compteur pour couvrir sa gamme. L'appareil se compose de deux parties séparées montées dans un coffret Nashton-major. L'élément numérique se trouve sur le côté gauche tandis que l'élément fonctionnel, c'est à dire la partie voltmétrique, est à droite. L'élément de lecture est un compteur mécanique à trois chiffres de 0,6cm de haut. Les gammes de tension sont de 1,00 à 9,99, 10,0 à 99,9 et 100 à 999, la précision étant supérieure à ±1,2% de la lecture effective ±1 chiffre. L'appareil est pourvu en outre d'éléments de droite, de résistance et capacité. Enfin, il peut être commandé à distance.

EE 31 770 *pour plus amples renseignements*

G. V. PLANER LTD

Windmill Road, Sunbury-on-Thames, Middlesex

GÉNÉRATEUR D'IMPULSIONS DE MILLI-MICROSECONDES

(Illustration à la page 188)

Ce générateur a été conçu principalement pour déterminer les temps de commutation dans les tubes de mémoire comme ceux, par exemple, du type à pellicule mince d'alliage.

La gamme d'impulsions couverte par cet instrument s'étend de 2 à 200 millimicrosecondes, la puissance de sortie permettant d'actionner des éléments de commutation nécessitant des courants pouvant aller jusqu'à 13A. La tension de sortie peut être variée de 1kV à moins de 1V.

Le specimen d'essai est fixé sur une tête de mesure à fiches avec boucle de captage appropriée. Le générateur est étudié pour fonctionner avec des sorties positives ou négatives à un taux de répétition des impulsions de 50Hz ou avec des sorties positives et négatives de rapport varié afin de permettre l'observation simultanée de la commutation ou de la non-commutation. Des points oscilloscopiques appropriés ainsi qu'une impulsion de sortie de synchronisation ont également été prévus. L'appareil fonctionne sur alimentation de 230V, 50Hz, et il peut être employé en liaison avec un oscilloscope du type à action rapide ou de laboratoire.

EE 31 771 *pour plus amples renseignements*

APPAREIL DE CONTRÔLE DE BOUCLES D'HYSTÉRÉSIS

(Illustration à la page 188)

Cet appareil a été prévu pour l'affichage sur oscilloscope cathodique de boucles d'hystérésis ainsi que pour déterminer la coercivité et la rémanence des matières magnétiques. Il permet de contrôler les revêtements magnétiques et, en particulier, ceux de bandes magnétiques d'enregistrement. Il convient également à l'évaluation d'alliages magnétiques sous forme de pellicule mince, de bande ou de fil.

Il comprend un amplificateur étalonné à faible bruit et trois têtes de mesure avec blocs d'alimentation correspondants pour couvrir les gammes suivantes:

(a) 50 à 2000 Oersteds. Un circuit magnétique en acier à grains orientés avec deux bobines exploratrices dans la position de champ uniforme est utilisé pour former la tête de mesure, prévue pour la mesure sur bande d'enregistrement magnétique, ur aciers magnétiques, etc.

(b) O à 10 Oersteds. La tête de mesure emploie un enroulement de commande à tour unique et un enroulement capteur à tour unique pour mesurer les pellicules toroïdales.

L'appareil est utilisé avec un oscilloscope normal (par exemple, Cossor type 1049).

EE 31 772 *pour plus amples renseignements*

W. G. PYE & CO. LTD

Granta Works, Cambridge

AMPLIFICATEUR pH INDUSTRIEL

(Illustration à la page 188)

Cet instrument est doté d'un circuit qui est essentiellement un amplificateur de tension continue du type à porteuse utilisant un modulateur à condensateur, un amplificateur de la porteuse et un démodulateur sensible aux phases avec un degré élevé de contreréaction totale. Ceci garantit un degré élevé de stabilité avec une linéarité quasi parfaite, cependant que les fluctuations normales de tension d'alimentation ne produisent pratiquement aucun changement dans le réglage de zéro ou la sensibilité. En raison de l'absence de tout courant d'entrée, on peut employer les électrodes de verre les plus robustes puisque leur très grande résistance ne produit pas d'erreurs de linéarité. Ceci est particulièrement important lorsqu'on travaille dans une gamme étendue de températures. La sensibilité est élevée (100 μA/pH) et l'on peut donc employer plusieurs enregistreurs extérieurs, indicateurs, contrôleurs et systèmes d'alarme à partir du même amplificateur et, si nécessaire, il peuvent être placés à quelque distance.

L'instrument assure la compensation de température automatique complète dans la gamme de 0 à 100°C et le modèle standard effectue des mesures de 2 à 12 pH.

EE 31 773 *pour plus amples renseignements*

AMPLIFICATEURS EN PONT DE COURANT ALTERNATIF ET BLOC D'ALIMENTATION

(Illustration à la page 189)

Ce matériel est fabriqué selon les spécifications du Royal Aeronautical Establishment, Farnborough. Il est entièrement transistorisé et à circuits imprimés, afin de le rendre plus compact et facile à produire.

L'amplificateur type IT 1-13-51 a été conçu pour l'emploi avec des accéléromètres à inductance push-pull et contient les circuits intégrateurs nécessaires à l'enregistrement du "déplacement" au moyen d'oscillographes, de galvanomètres ou d'enregistreurs à bande magnétique de modulation de fréquence dans la gamme de 5 à 100 Hz.

L'amplificateur type IT-12-51 a été étudié pour l'emploi avec des extensomètres à fil résistant et comporte des résistances en pont d'une extrême stabilité et à coefficients de température accordée. Cet élément enregistre également le "déplacement" au moyen d'oscillographes, de galvanomètres ou d'enregistreurs a bande magnétique de modulation de fréquence et sa gamme de fréquences s'étend de zéro à environ 1 kHz.

Le bloc d'alimentation type IT-1-13-52 comprend les circuits d'alimentation de six, de deux ou de l'un ou l'autre des types précités d'amplificateur et il fournit aussi le signal de fréquence porteuse pour l'excitation des ponts transducteurs et la démodulation des six amplificateurs. La fréquence porteuse est de 2 ou de 3 kHz, le changement s'effectuant par liaison intérieure.

Tous ces appareils fonctionnent sur tension continue normale d'avion de 27 à 29 V. Il existe également des éléments à indicateur pour les deux types d'amplificateur.

EE 31 774 *pour plus amples renseignements*

RACAL INSTRUMENTS LTD

Western Road, Bracknell, Berkshire

FRÉQUENCEMÈTRE NUMÉRIQUE

(Illustration à la page 189)

Le fréquencemètre SA.505 combine les techniques les plus récentes du transistor en un instrument compact et autonome, et il convient à toutes les applications de laboratoire dans le domaine de la mesure de fréquence, de période et d'intervalle de temps.

Un indicateur à sept chiffres en série est incorporé au fréquencemètre pour l'affichage continu. On peut, en outre, effectuer la mesure de fréquence directe d'ondes sinusoïdales et de signaux d'impulsions dans la gamme de 0 à 10 MHz, ainsi que la mesure d'intervalle de temps entre deux impulsions négatives ou positives dans la gamme de 0,1 μsec à 10^4 sec. La mesure de période peut aussi être effectuée dans 1,10 et 100 cycles de la fréquence inconnue, avec une précision allant jusqu'à 1 partie dans 10^6. La précision de la mesure de fréquence est de ±1 compte ± la stabilité du cristal intérieur qui est de 1 partie dans 10^7. On peut, en outre, assurer le fonctionnement à partir d'un étalon de fréquence extérieur de 100 kHz ou 1 MHz.

L'instrument fournit des sorties numériques sous forme de fermetures de contact de relais, permettant une lecture à distance directe ou en variante. Un enregistrement numérique imprimé peut être obtenu en utilisant le sérialisateur à 10 directions type SA.138 actionnant une machine imprimeuse Addo X.

EE 31 775 *pour plus amples renseignements*

W. H. SANDERS (ELECTRONICS) LTD

Gunnels Wood Road, Stevenage, Hertfordshire

DÉTECTEURS DIRECTIONNELS MULTI-TROUS

(Illustration à la page 189)

Ces détecteurs directionnels de mesures multi-trous sont fournis dans les grandeurs 12, 14, 15, 16, 18 et 22 de guide d'ondes et couvrent la bande complète de 3,95 GHz à 40 GHz.

Ils emploient des ouvertures circulaires comme éléments de couplage entre les parois larges des deux guides d'ondes, disposés en faisceau de Tschebyshef. L'avantage principal de ce dispositif réside dans le fait que la directivité peut être effectuée à très large bande sans détérioration près des extrémités de bande, comme dans le cas du faisceau binome. Il est donc possible de réaliser des détecteurs ayant une directivité supérieure à 40 dB dans la gamme complète de fréquences, avec une sensibilité de fréquence de couplage de ±0,5 dB et une précision de couplage moyen de ±0,3 dB.

EE 31 776 *pour plus amples renseignements*

STANDARD TELEPHONES & CABLES LTD

Connaught House, Aldwych, London, W.C.2

TRANSISTORS EPITAXIAUX

L'épitaxe est un processus dans lequel on forme une couche de matière semi-conductrice par dépôt de gaz, tel que le bi-iodure de germanium, a une température élevée, sur un cristal "germe" à une temperature inferieure. La matière ainsi déposée a la même orientation piézoélectrique que le germe.

Dans la plupart des transistors à jonction par diffusion, la matière formant la partie collectrice doit avoir une grande résistivité afin d'atteindre une tension disruptive collectrice élevée. Une limite a eté imposée jusqu'ici à la minceur de la partie collectrice par les problèmes mécaniques posés par la manipulation de transistors faits de tranches très minces de matière. Par conséquent, une tension disruptive élevée n'a pas été compatible avec de bonnes caractéristiques de saturation (c'est à dire une faible résistance série collecteur).

Dans le cas des transistors épitaxiaux, on dépose une couche très mince de matière à grande resistivité sur un des côtés d'une tranche de matière à faible résistivité. Le transistor est ensuite fabriqué par diffusion de corps solides dans la matière à grande résistivité, par la méthode courante. La matière à faible résistivité (germe) agit simplement comme "appui" des transistors et leur donne la puissance mécanique.

Le transistor qui en résulte a des caractéristiques de saturation nettement meilleures et l'emploi de l'épitaxie assure une plus grande souplesse à la réalisation de dispositifs car l'interdépendance de certains des paramètres du transistor est considérablement réduite. Ceci peut donner des temps de commutation rapides et une capacité de sortie plus faible.

EE 31 777 *pour plus amples renseignements*

VENNER ELECTRONICS LTD

Kingston By-Pass, New Malden, Surrey

VOLTMÈTRE-OHMMÈTRE NUMÉRIQUE

(Illustration à la page 189)

Cet instrument peut mesurer des tensions de 1 mV à 1,1 kV c.a. ou c.c. et une résistance allant jusqu' à 1,1 mégohm.

Les résultats sont clairement affichés par quatre indicateurs de projection en série d'un nouveau modèle, avec indication automatique de signes, et peuvent être enregistrés par couplage direct à un imprimeur Venner ou à un élément de commande de reperforateur.

Le voltmetre-ohmmètre accomplit de nombreuses autres fonctions numériques et il se prête au fonctionnement en tant qu'appareil unique ou pour l'inclusion dans n'importe quel système d'enregistrement de données.

Il n'emploie pas de commutateurs ou de relais pas-à-pas et il se compose d'étages à fiches transistorisés. Il fournit des lectures stables avec entrée fluctuante et il est d'un fonctionnement simple.

EE 31 778 *pour plus amples renseignements*

Résumés des Principaux Articles

Circuits d'automation à tubes à cathode froide par R. S. Sidorowicz

Résumé de l'article aux pages 138 à 143

Les éléments suivants de circuits à tubes à cathode froide sont décrits dans cet article: (1) quatre amplificateurs d'impulsions différents; (2) quatre circuits à retard ou univibrateurs différents; (3) trois compteurs binaires, trois compteurs toroïdaux et un compteur toroïdal reversible ou bidirectionnel; (4) trois circuits logiques "OU" différents et deux circuits logiques "ET"; (5) une matrice de décalage ou registre; (6) six oscillateurs et multivibrateurs différents; (7) un circuit de commande pour tube d'affichage numérique. Les circuits sont basés sur des résistances, des condensateurs et trois types de triodes à cathode froide (types: XC18, XC23 et XC24). Un tube stabilisateur à cathode froide subminiature, type ZC12T est utilisé comme source de tension stable de polarisation ou d'amorçage. Tous les éléments de circuits sont à auto-amorçage et ils reviennent automatiquement à leur position de repos après avoir complété leur cycle de fonctionnement. Ces elements forment une série logique de circuits à tubes à cathode froide pouvant être utilisés pour l'étude de systèmes d'automation industriels. La méthode consistant à combiner les circuits de façon à construire un ensemble assez complexe est demontrée par trois exemples pratiques; une échelle électronique, un compteur de lots à programme et un dispositif de contrôle électronique. Les systèmes formés de circuits à rubes à cathode froide emploient des contacteurs mécaniques, des commutateurs

et des photorésistances comme dispositifs d'entrée, ceux de sortie étant constitués par des relais électromagnétiques. Les systèmes nécessitent une alimentation stabilisée unique de + 180V et peuvent fonctionner à des vitesses de plus de 100Hz.

Un convertisseur analogique-numérique à action rapide par N. Winterbottom et J. S. Walters

Résumé de l'article aux pages 144 à 149

Dans les nombreux cas où de grandes quantités de données sont dépouillées par ordinateur électronique, ces données se trouvent tant sous forme numérique qu'analogique dans diverses parties du dispositif. En pareils cas, il est donc nécessaire de convertir les données analogiques en données numériques.

Les auteurs décrivent un convertisseur analogique-numérique à action rapide, capable d'effecteur 55 000 conversions par seconde d'une tension analogique à un code binaire à huit chiffres. Ce convertisseur utilise des transistors comme éléments actifs.

Une nouvelle horloge à indications numériques par A. Russell

Résumé de l'article aux pages 150 à 154

L'auteur décrit la conception et le fonctionnement d'une nouvelle horloge à indications numériques qui enregistre le mois, le jour, l'heure, la minute, le numéro de l'expérience et le numéro de l'essai sur des indicateurs en série éclairés. Tous ces renseignements, ainsi que l'année, sont fournis en mode le lecture série et peuvent être enregistrés sur bande de papier perforé ou tapés sur machine à écrire électrique à fonctionnement solénoïdal. La méthode de réenclenchement employée permet d'établir rapidement de nouvelles configurations. L'étalon existant de fréquence de laboratoire fournit les impulsions à intervalles réguliers actionnant la partie calendrier, qui sert donc de contrôleur de la précision à long terme de cet étalon de fréquence.

Un générateur de fonctions de pression à usages multiples par J. Morrison

Résumé de l'article aux pages 155 à 159

L'auteur décrit un générateur de fonctions de pression pour calculateur analogique, pouvant fournir des fonctions sinusoïdales, carrées, triangulaires, de rampe, à plots ou d'impulsions, d'une précision de ½% de l'échelle totale en fréquence et en amplitude. La gamme de fréquences s'étend de 0,001Hz à 100Hz, et le générateur peut être commandé à partir du calculateur ou indépendamment.

Un diagramme d'étude pour antennes à réflecteurs paraboliques par C. O. Titley

Résumé de l'article aux pages 162 à 163

Le réflecteur parabolique se caractérise par une surface de réflexion intérieure ayant la forme de la surface de réflexion produite par la rotation d'une parabole autour de son axe de symétrie. Ce réflecteur a la propriété particulière de produire un rayonnement en phase sur toute son ouverture, lorsqu'il est éclairé de manière uniforme, à son foyer, par une source ponctuelle. Ceci explique les nombreuses applications que trouvent les miroirs paraboliques dans l'optique et la radioélectricité. Le diagramme présenté ici a été conçu afin d'aider les travaux d'étude de réflecteurs pour antennes radioélectriques.

Filtres passe-bande en échelle en céramique piézoélectrique par R. C. V. Macario

Résumé de l'article aux pages 171 à 177

La céramic piézoélectrique, qui se caractérise par des coefficients de couplage électromécanique élevés et des facteurs de surtension moyens, se prête fort bien à la fabrication de filtres passe-bande en échelle d'un aspect attrayant et en forme de petits disques circulaires à résonnance radiale en liaison avec des condensateurs ou sans ces derniers.

Le présent article examine les possibilités de réalisations pour divers circuits, présentées sous forme de graphiques dont les tables sont constituées par des données précises d'étude et de calcul. Ces dernières sont basées sur la théorie des paramètres d'image, corroborée par comparaison avec les réponses de filtres réels. L'article considère également les gammes de fréquence médiane, de largeur de bande et d'impédance d'image pouvant être obtenues.

Elektronische Geräte auf der Ausstellung der PHYSICAL SOCIETY

Beschreibung einer kleinen Auswahl der auf der 45. Austellung der Physical Society vom 16. bis 20. Januar in London gezeigten elektronischen Geräte nach Angaben der Hersteller

Übersetzung der Seiten 184 bis 189

ADVANCE COMPONENTS LTD

Roebuck Road, Hainault, Ilford, Essex

TON-SPEKTROMETER

(Abbildung Seite 184)

Der Advance-Tonanalysator ist ein genaues, stabiles und leichtes Gerät mit eingebauten Batterien, in sich abgeschlossen und nach fortschrittlichsten Richtlinien für Tonmessungsaufgaben und -analysen entwickelt. Mittels der eingebauten Oktavfilter können schnelle Analysen selbst komplexer Spektren vorgenommen werden. Mit einem geeigneten Schwingungsaufnehmer können auch Untersuchungen mechanischer Schwingungen im Tonfrequenzbereich durchgeführt werden. Der SPM.1 ist besonders für Geräuschmessungen an Flugzeugen, Fahrzeugen und Maschinen geeignet sowie für Analyse von Geräuschen in Büroräumen, in denen der Sprach-Störpegel wichtig ist.

Das Gerät besteht aus einem sehr kleinen Kristallmikrofon, einem sechsstufigen, durch hohe Gegenkopplung stabilisierten Verstärker, 8 wahlweise umschaltbaren Bandfiltern und einem in Dezibel geeichten Drehspulinstrument. Ein eingebautes Dämpfungsglied mit 5 Stufen von je 10 dB überstreicht einen Bereich von 30...80 dB, und ein zusätzliches Dämpfungsglied hat 3 Stufen von je 20 dB für den Bereich 0...60 dB. Der Gesamtbereich des Gerätes einschliesslich der Instrumentanzeige liegt zwischen 20 dB und 150 dB bezogen auf den Standard-Tondruckpegel $2 \cdot 10^{-4}$ µbar ($-2 \cdot 10^{5}$ N/m²). Tonfrequenzen im Bereich von 20 Hz...12 kHz können gemessen und mit Hilfe der eingebauten Filter in Oktavbändern analysiert werden. Die eingebauten Batterien können mit dem Drehspulinstrument geprüft werden.

EE 31 751 *für weitere Einzelheiten*

AIRMEC LTD

High Wycombe, Buckinghamshire

OSZILLOGRAF MIT HOHER SCHREIBGESCHWINDIGKEIT

(Abbildung Seite 184)

Der Oszillograf Type 294 ist ein vielseitiges Laborgerät. Sein umfassender Ablenkzeitbereich, der Breitbandfrequenzgang (0...50 MHz) und die kurze Anstiegszeit des Y-Verstärkers eignen sich besonders für Arbeiten mit kurzen Impulszeiten. Durch die genaue Eichung der Zeitablenkung und des Ablenkungsverstärkers, die vorgesehenen Zeit-und Spannungsmarken und umfangreichen Vorkehrungen für Zeitablenkverzögerung und Triggerung ist das Gerät für universelle Labormessungen geeignet.

Mit der internen Zeitablenkung synchronisierte Ausgangsimpulse ermöglichen Verwendung für Arbeiten mit komplexen elektronischen Anlagen. Einmalige Zeitablenkung, regelbare Flutbeleuchtung des Rasters und umschaltbare Nachbeschleunigungspegel fördern das Fotografieren der Spur. Die farbengekennzeichneten, logisch angeordneten Bedienungsknöpfe erleichtern zuverlässiges Arbeiten.

Das gesamte, von einer bekannten französischen Firma entwickelte und von Airmec unter Lizenz gebaute Gerät besteht aus dem Sichtgerät, das zur besseren Beobachtung schräg in einem Stahlrohrstand mit Laufrollen angeordnet ist, und dem im Stand unten eingebauten Netzgerät. Filtrierte, zwangsläufige Luftkühlung und Verwendung von Qualitäts-Bauelementen tragen zu höchster Betriebssicherheit bei.

EE 31 752 *für weitere Einzelheiten*

CAWKELL RESEARCH & ELECTRONICS LTD

Scotts Road, Southall, Middlesex

FERNSEH-SPEICHEROSZILLOGRAF

(Abbildung Seite 184)

Das Tele-Remscope ist ein Bildmonitor für Fernsehanlagen im Kurzschlussbetrieb, dessen Hauptvorteil ist, dass das Bild durch Betätigung einer Drucktaste oder eines Schalters "festgehalten" werden kann.

Das Tele-Remscope kann mit 405 oder 625 Zeilen und 50 Hz Bildfrequenz oder 525 Zeilen und 60 Hz betrieben werden und benötigt ein 1,5 V positivgehendes Video-Eingangssignal. Jede beliebige Bildzahl von 1...4 kann gespeichert und bis zu 15 Minuten auf dem Schirm der English Electric Speicherröhre E 702 gezeigt werden. Der Schirm hat einen Durchmesser von 10 cm und ruft eine gelb-grüne Fluoreszenz (P 20) hervor.

EE 31 753 *für weitere Einzelheiten*

DAWE INSTRUMENTS LTD

99-101 Uxbridge Road, Ealing, London, W.5

NF-GERÄUSCHGENERATOR

(Abbildung Seite 184)

Der Geräuschgenerator für sehr niedrige Frequenzen Type 418 erzeugt elektrische Geräusche mit einem Frequenzspektrum, das von 0 ... 200 Hz innerhalb +0,5 dB gleichförmig ist.

Die Geräuschquelle des Gerätes ist eine Thyratronröhre, die im Spektrum des Tonbereiches gleichförmiges elektrisches Rauschen erzeugt. Die Geräuschleistung wird durch ein verhältnismässig breitbandiges Filter mit einer Mittelfrequenz von 2 kHz in eine Modulator-Schaltung gespeist, in der sie mit dem Ausgang eines örtlichen 2 kHz-Festfrequenz-Oszillators gemischt wird.

Der Modulatorausgang geht durch ein Tiefpassfilter, um die HF-Modulationsprodukte zu entfernen. Das NF-Signal wird an einen gleichspannungsgekoppelten Verstärker mit niederohmigem Kathodenverstärker angelegt, der die

Ausgangsklemmen und das Anzeigeinstrument speist. Das Messgerät ist in Effektivwerten des regellosen Rauschens geeicht. Der Ausgangspegel kann mittels eines Potentiometers, das die Verstärkung ändert, kontinuierlich geregelt werden. Hohe Stabilität des eingestellten Leistungspegels und geringe Gleichspannungsdrift werden durch Benutzung stabilisierter Hoch- und Niederspannungsquellen und durch reichliche Gegenkopplung im Verstärker erzielt. Der grosse dynamische Bereich des Verstärkers gewährt regellose Amplitudenverteilung mit unwesentlichem Abkappen der Wellenform bis zur vollen Nennleistung. Das Gerät ist eine Entwicklung der von D. A. Bell und A. M. Rosie der Universität Birmingham ausgearbeiteten Originalschaltung.

EE 31 754 *für weitere Einzelheiten*

NF-WOBBELSENDER

(Abbildung Seite 185)

Der NF-Wobbelsender Type 444 befriedigt den Bedarf für einen verzerrungsarmen Oszillator mit RC-Abstimmung, der in einem Bereich die Frequenzen 5 Hz ... 5 kHz überstreicht. Der Oszillator gibt eine konstante Ausgangsspannung ab und hat eine Frequenzskala mit genauer logarithmischer Eichung. Die Wobbelsteuerung erfolgt durch einen Eigenmotorantrieb, der so ausgelegt ist, dass verschiedene Wobbelgeschwindigkeiten zwischen beliebigen Frequenzgrenzen möglich sind. Automatische Umkehr der Wobbelrichtung bei Erreichung der Grenzfrequenzen kann eingestellt werden. Andererseits kann jederzeit durch Fernsteuerung die Richtung ungekehrt oder die Überstreichung angehalten werden.

Im wesentlichen besteht die Schaltung aus einer frequenzbestimmenden Brücke, die einen symmetrischen Gegentaktverstärker mit Kathodenverstärkerausgang speist.

Das frequenzbestimmende Netzwerk besteht aus einer abgewandelten Wien-Brücke, in der die Arme mit reinem Widerstand durch komplexe RC-Netzwerke ersetzt wurden. Bei einem Kapazitätsverhältnis des Abstimmkondensators von 10 : 1 erweitern sie den Frequenzbereich konstanter Phasenverschiebung auf über 1000 : 1. Der besonders für eine wirklich logarithmische Skala konstruierte Abstimmkondensator hat eine Rotorspindel, die laufendes Drehen ohne Anschlag erlaubt.

Durch einen Motorantrieb mit Getriebekasten sind im Bereich 0,2 ... 10 Oktaven/min sechs Wobbelgeschwindigkeiten einstellbar, und durch einstellbare Grenzschalter kann jeder beliebige Bereichabschnitt überstrichen werden.

Die Überstreichung kann auch mittels der Fernbedienungseinheit Type 444/1 gesteuert werden. Das Durchlaufen der Frequenzen kann dann vorwärts oder rückwärts erfolgen und jederzeit gestoppt werden. Andererseits kann die Frequenzskala manuell auf jede beliebige Frequenz eingestellt werden.

Das Brückensignal wird in den symmetrischen Gegentaktverstärker gespeist, der direkt mit der folgenden Kathodenverstärkerstufe gekoppelt ist. Die Gegenkopplung erfolgt von der Kathode der Ausgangsstufe zum Gitter der Verstärkerröhren. Im Widerstandsarm der Brücke ist ein wärmeempfindliches Widerstandselement vorgesehen, das den Amplitudenpegel der Schwingungen im geradlinigen Bereich des ausgeglichenen Verstärkers stabilisiert. In Verbindung mit der starken Gegenkopplung harmonischer Frequenzen wird dadurch gute Stabilität und geringe Verzerrung der Sinuswelle am Ausgang gewährleistet.

Innerhalb der gesamten Gegenkopplungsschleife findet auch eine geregelte Mitkopplung der Ausgangsstufe statt, die den Ausgangswiderstand des Kathodenverstärkers praktisch auf Null reduziert. Die Ausgangsklemmen werden vom Kathodenverstärkerausgang über ein Doppelpotentiometer gespeist.

An den Klemmen stehen Gegentaktausgangsspannungen bis zu 12 V bei einem Abschluss von 10 kΩ zur Verfügung. Der Ausgangspegel ist kontinuierlich von Maximum bis Null regelbar.

EE 31 755 *für weitere Einzelheiten*

DYNATRON RADIO LTD

Maidenhead, Berkshire

TESTGERÄT FÜR DIE KERNTECHNIK

Im Testgerät Type N 107 sind ein Doppelimpulsgeber und ein Anzeigeoszillograf kombiniert. Es wurde besonders für die Wartung der in der Kerntechnik üblichen Geräte entwickelt wie z.B. Impulsverstärker, Diskriminatoren, Untersetzer, Mittelwertmesser und Impulshöheanalysatoren. Ein Hauptmultivibrator steuert die Impulsfolgefrequenz des Impulspaares.

Das Haupt-Impulsfolgefrequenzsignal triggert (1) einen Impulsbreitegeber und (2) eine abfallende Sägezahnstufe. Der in (1) erzeugte feste Impuls wird amplitudenbegrenzt und dann einem Amplitudensteuerpaar zugeführt, so dass positiv- oder negativgehende Impulse gewählt werden können. Ein doppelter Kathodenverstärker speist entweder die Ausgangsklemmen des Testgerätes oder einen weiteren Abschwächungsregler. Die in (2) eingeleitete Kippschwingung liefert die X-Zeitablenkung für den X-Verstärker des Oszillografen und speist auch ein Amplitudentor. Sowie der Sägezahn den durch den Impulsabstandregler eingestellten Torpegel kreuzt, wird ähnlich wie bei (1) in einem Impulsbreitegeber der bewegliche (zweite) Impuls erzeugt, der genau so behandelt wird wie der erste (feste) Impuls, d.h. begrenzt, einem Amplitudensteuerpaar und dann dem Ausgangskathodenverstärker zugeführt wird. Durch den Impulsgeber steht daher ein positiv- oder negativgehendes Impulspaar mit unabhängig voneinander steuerbarer Breite und Amplitude zur Verfügung, in dem der Abstand der Impulse voneinander regelbar ist. Der feste Impuls oder der bewegliche zweite Impuls können bei Nichtbenutzung abgeschaltet werden.

Die Geräteausrüstung wird durch einen Y-Verstärker vervollständigt, der auf Breitbandfrequenzgang und mittlere Verstärkung oder hohe Verstärkung mit beschränktem Frequenzgang umstellbar ist. Amplituden werden mittels eines Y-Verschiebungssystems gemessen.

EE 31 756 *für weitere Einzelheiten*

E.M.I. ELECTRONICS LTD

Hayes, Middlesex

VORVERSTÄRKER

Der Vorverstärker Type 7/5 wird im Programm der Einschub-Bausteine für den Oszillografen W.M.16 hergestellt.

Der Baustein hat dieselben Anwendungsmöglichkeiten wie der Breitbandverstärker 7/1, gibt jedoch zusätzlich bei Wechselspannungskopplung die 10fache Verstärkung, wodurch bei verringerter Bandbreite eine Höchstempfindlichkeit von 5 mV/cm erzielt wird.

Der Vorverstärker wird von vorn in den Träger des W.M.16 eingeschoben und somit an die Versorgung des Hauptgerätes angeschlossen.

Ein dreistufiger Eingangswahlschalter stellt folgende Kombinationen von Bandbreite und Empfindlichkeit ein:

Gleichspannung: Anstiegszeit 10 ns; Bandbreite 0 ... 40 MHz; Empfindlichkeit 50 mV/cm ... 20 V/cm in neun umschaltbaren und geeichten Bereichen.

Wechselspannung: Anstiegszeit 10 ns, Bandbreite 3 Hz ... 40 MHz; Empfindlichkeit 50 mV/cm ... 20 V/cm.

Wechselspannung × 10: Anstiegszeit 16 ns; Empfindlichkeit 5 mV/cm ... 2 V/cm in neun umschaltbaren und geeichten Bändern. Eingangs-Zeitkonstante 0,05 s.

EE 31 757 *für weitere Einzelheiten*

DIFFERENZVERSTÄRKER

(Abbildung Seite 185)

Der Differenzverstärker 7/6 ist ein weiterer Einschub-Baustein für den Oszillografen W.M.16. Er bietet die Möglichkeit, zwei Eingänge entweder getrennt oder als Differenz, entweder gleich- oder wechselspannungsgekoppelt zu beobachten. Amplitudenmessungen können entweder mittels Skala oder Rasterscheibe durchgeführt werden. Nur der Eingang B bildet eine Ausnahme, wenn er für Gleichspannungskopplung benutzt wird. In dieser Position wird die Messung auf der Rasterscheibe vorgenommen.

Jeder Kanal hat einen getrennten Dämpfungsregler für Änderung der Empfindlichkeit von 50 mV/cm...20 V/cm

in neun Bereichen. Kontinuierliche Regelung der Verstärkung zwischen den Rasterpunkten des Dämpfungsgliedes erfolgt mittels eines Feinreglers.

Die Bandbreite ist 0 ... 25 MHz oder 4 Hz ... 25 MHz und die Anstiegszeit 16 ns. Bei voller Verstärkung ist das Unterdrückungsverhältnis über das Durchlassband bei Gleichspannungskopplung besser als 100 : 1 und von 10 Hz ... 25 MHz bei Wechselspannungskopplung besser als 100 : 1.

EE 31 758 *für weitere Einzelheiten*

ELECTRONIC TUBES LTD

Kingsmead Works, High Wycombe, Buckinghamshire

SPEICHERPHOSPHORE

Die Eigenschaften einer mit dem neuen Schirmmaterial ausgerüsteten Standard-Elektronenstrahlröhre wurden vorgeführt. Wenn der Schirm erstmalig erregt wird, entsteht eine blaue Fluoreszenz, die der eines üblichen, zweischichtigen Phosphors mit langer Nachleuchtdauer ähnlich ist. Darauf folgt Nachleuchten, dessen Dauer der von zwei Phosphorschichten vergleichbar ist; jedoch ist die Nachleuchtfarbe des Schirmes grün.

Aber selbst nachdem das Nachleuchten vollständig abgeklungen ist, kann von diesem Schirm noch weitere Information abgelesen werden. An den Stellen des Phosphors, die erregt wurden, sind noch gewisse Energiebeträge gespeichert, die bei infraroter Beleuchtung freigegeben werden. Die Helligkeit des gespeicherten Bildes hängt von der Intensität der infraroten Quelle ab, von der auch die bis zur Bildauslöschung zur Besichtigung zur Verfügung stehende Zeit beeinflusst wird. Ein bestimmter Energiebetrag ist gespeichert: erhöhte infrarote Quellenintensität reduziert die Betrachtungsdauer und umgekehrt.

Es ist weiterhin sehr zweckdienlich, dass das gespeicherte Bild nicht nur einmal bis zur Auslöschung betrachtet werden kann, sondern dass mehrere kurze Betrachtungen hintereinander und, wenn erforderlich, im Abstand von mehreren Minuten erfolgen können.

Natürlich hängt in einem derartigen Speicher die gespeicherte Energie direkt von der Erregungsintensität ab. Der Speicherwirkungsgrad ist verhältnismässig gering und hohe Schreibgeschwindigkeiten sind unmöglich. Deshalb wird der Phosphor auch nicht für Röhren mit niedrigen Anodenspannungen empfohlen, da die Energie in diesen Fällen zu gering ist.

Grundsätzlich kann der Phosphor für jede beliebige von Electronic Tubes Ltd hergestellte Elektronenstrahlröhre benutzt werden, jedoch werden Röhren für niedrige Spannungen des begrenzten Nutzens wegen nicht mit diesem Phosphor hergestellt.

EE 31 759 *für weitere Einzelheiten*

ELLIOTT BROTHERS (LONDON) LTD

Century Works, Lewisham, London, S.E.13

AUTOMATISCHER LEITUNGSPRÜFER

(Abbildung Seite 186)

Dieses Gerät wurde zur laufenden vollautomatischen Prüfung komplexer Kabelbäume oder ähnlicher Konstruktionen durch Programmierung des Gerätes mit den Testbedingungen entwickelt.

Das vorgeführte Modell kann die folgenden Tests an bis zu 600 Leitungsabschlüssen ausführen, wobei jeder Abschluss gegen jeden anderen geprüft wird:

(1) Widerstand 0... 1000Ω.
(2) Stromfähigkeit nicht höher als 0,5Ω.
(3) Isolation zwischen Leitungen höher als 20 MΩ.
(4) Isolation gegen Erde höher als 20 MΩ.

Durch ein vorgegebenes Programm können alle aufgeführten Prüfungen für jedes beliebige Abschlusspaar ausgeführt werden. Die Befehle sind auf einem 25,4 mm breiten Magnetband entsprechend einer Kabel- oder Abschlussaufstellung für die zu prüfende Leitungsanordnung aufgezeichnet. Diese Leitungsanordnung wird mit dem Leitungsprüfer in genormter Nummernfolge verbunden, die mit der Abschlussaufstellung und den Programmnummern übereinstimmt.

Mit 600 Abschlüssen sind 180 300 Prüfkombinationen möglich. Dieses umfassende Programm kann auf einem 3 m langen Magnetband aufgezeichnet werden.

Weitere Entwicklungsarbeiten werden den Einsatz des Gerätes zur Prüfung fast aller elektronischen/elektrischen Schaltungen mit geringstem Arbeitsaufwand ermöglichen. Eine automatische Fehlerregistrierung mittels eines Code-Druckwerkes ist auch im Entwicklungsstadium.

EE 31 760 *für weitere Einzelheiten*

NORMALFREQUENZ-EMPFÄNGER

Dieses Gerät ist für den Empfang der Droitwich 200 kHz — Normalsendung bestimmt, deren Konstanz besser als ungefähr $20 \cdot 10^{-9}$ ist und den zusätzlichen Vorteil hat, fast täglich um 10.30 GMT mit dem Caesium-Resonator des National Physical Laboratory verglichen zu werden. Die Ausgangsleitung dieses Empfängers ist von der Modulation vollkommen unabhängig.

Der Normalfrequenz-Monitor erzeugt die folgenden Frequenzen von einer hochohmigen Quelle: Sinuswellen mit 5 V doppeltem Spitzenwert auf 50, 100, 200 und 400 Hz sowie 20 und 200 kHz; Rechteckwellen mit 2 V doppeltem Spitzenwert auf 50, 100, 200 und 400 Hz.

Im Sonderauftrag können andere Mehrfache der niedrigen Frequenzen mit Ausnahme der 200 kHz—und 20 kHz—Ausgänge geliefert werden.

An jede der Niederfrequenzquellen können zwei Regel-Verstärker geschaltet werden und Leistungsapparate treiben. Sie geben eine Ausgangsspannung bis zu 20 V_{eff} ab. Ein Monitorlautsprecher ist auch vorgesehen.

EE 31 761 *für weitere Einzelheiten*

VERSTÄRKER MIT VERHÄLTNISANZEIGE

(Abbildung Seite 186)

Dieses Gerät ist ein selektiver Verstärker, dessen Verstärkung mittels einer elektrischen Spannung geregelt werden kann, und dem ein Brückengleichrichter und Anzeigeinstrument nachgeschaltet sind.

Die gleichgerichtete Ausgangsspannung kann mittels eines externen Schaltkreises über einen Gleichstromverstärker zur Verstärkungsregelung des Systems zurückgeführt werden. Ist der Schalter geschlossen, so ist die Instrumentanzeige über einen Eingangsspannungsbereich von 50 dB innerhalb 1% konstant. Bei offenem Schalter wird die Verstärkung während einer beträchtlichen Zeitdauer durch eine Schaltung mit einer Zeitkonstanten von einer halben Stunde weitgehend konstant gehalten. Jede Pegeländerung der Eingangsspannung wird dann am Instrument angezeigt.

EE 31 762 *für weitere Einzelheiten*

MEHRKANAL-MAGNETBANDGERÄT

(Abbildung Seite 186)

Das Gerät hat ein Bandtransportsystem mit doppelten Bandantriebsrollen und Aufwickelvorrichtungen. Durch Drucktasten können die fünf Bandgeschwindigkeiten eingestellt werden. Bei einer Geschwindigkeit von 76,2 cm/s können Frequenzen bis zu 75 kHz aufgenommen werden.

Mit einer Geschwindigkeit von 4,76 cm/s und 25,4 mm breitem Magnetband mit dünnem Trägermaterial steht eine Höchstaufnahmezeit von drei Tagen zur Verfügung. Automatische Bandumkehr ist möglich, da Aufnahme- und Wiedergabeköpfe in zweifacher Anordnung vorgesehen sind. Zur Standardausrüstung gehören fünf Einsteckköpfe. Durch die Laufwerkkonstruktion, die die mit den Köpfen in Berührung stehende Bandlänge durch die doppelten Antriebsrollen von den Ablauf- und Aufnahmevorrichtungen und durch diese auftretenden Störungen isoliert, sind die Geschwindigkeitsschwankungen sehr gering.

Das Gerät ist volltransistorisiert mit weitgehender Benutzung gedruckter Schaltungen. Durch Einschubbausteine können sowohl direkte wie auch F.M.-Aufzeichnungen vorgenommen werden. Fernbedienung ist vorgesehen. Hauptverwendung des Gerätes ist für Fernmesswerterfassung und Flugerprobung von Fernlenk-Flugkörpern und Flugzeugen.

EE 31 763 *für weitere Einzelheiten*

ENGLISH ELECTRIC VALVE CO. LTD

Chelmsford, Essex

BILDVERSTÄRKER

Die mit hoher Verstärkung arbeitende Bildverstärkerröhre hat eine Eingangsphotokathode, fünf Sekundärelektronen-Dynoden und einen Ausgangsleuchtschirm. Für den Betrieb sind eine Fokussierspule, optische Eingangs- und Ausgangssysteme und Netzgeräte erforderlich.

Das zu verstärkende Bild wird auf die Photokathode an einem Ende der Röhre fokussiert, die Photoelektronen werden beschleunigt und auf den ersten dünnen Dynodenfilm fokussiert. Für jedes Primärelektron werden 5 oder 6 Sekundärelektronen von der anderen Seite der Dynode abgegeben, die ihrerseits beschleunigt und auf die zweite Dynode fokussiert werden. Dieser Vorgang wird an jeder Dynode wiederholt; die von der letzten Dynode abgegebenen Sekundärelektronen werden auf den Leuchtschirm zu beschleunigt und bilden die verstärkte Wiedergabe des Originalbildes geringer Lichtstärke.

Röhren mit einer Photonverstärkung von 100 000 bis 200 000 wurden hergestellt. 7000fache Verstärkung erfolgte in der fünfstufigen Elektronenvervielfachung und die weitere Verstärkung durch das Bombardement des Fluoreszenzschirmes.

Der wirksame Durchmesser der Dynoden ist 25,4 mm. Der Durchmesser des Bildes kann zwischen der Photokathode und der ersten Dynode verkleinert werden, so dass gegebenenfalls das Eingangsbild nicht auf 25,4 mm beschränkt zu werden braucht. In ähnlicher Weise können grössere Bilder auf dem Schirm hervorgerufen werden, wo das erforderlich erscheint.

EE 31 764 *für weitere Einzelheiten*

BISTABILE ELEKTRONENSTRAHL-SPEICHERRÖHRE

Für die Auftreffelektrodengruppe der E 710 Speicherröhre für Direktbetrachtung wurden neue Entwicklungswege eingeschlagen. Die neue Konstruktion ist weniger der Gefahr ausgesetzt, durch einen zufällig angelegten hohen Strahlstrom beschädigt zu werden, wodurch die zugeordneten Schaltungen vereinfacht werden können.

Die Röhre speichert Information für unendliche Zeit und kann die gespeicherte Wellenform entweder dauernd oder mit Unterbrechung wiedergeben. Zwei oder mehr Signale können gespeichert, gleichzeitig sichtbar gemacht und augenblicklich gelöscht werden, wenn sie nicht länger erforderlich sind.

Die E 710 hat einen Strahlerzeuger, dessen Strahl elektrostatisch abgelenkt und fokussiert dem Speichergitter mit einem Punktdurchmesser von 0,25 mm ein Ladungsmuster aufdrückt. Ein zweiter Strahlerzeuger überstreicht das Speichergitter dauernd, um das Signal aufrecht zu erhalten und auf dem Phosphor darzustellen.

EE 31 765 *für weitere Einzelheiten*

MARCONI INSTRUMENTS LTD

St. Albans, Hertfordshire

NF-GENERATOR

(Abbildung Seite 187)

Dieser neue Generator erzeugt Sinus-, Rechteck- und Kippschwingungen, die durch Schalterbetätigung gewählt werden können. Der durchstimmbare Frequenzbereich von 0,0033 Hz ... 1 kHz ist in fünf überschneidende Bänder unterteilt. Die Hochleistungs-Umschaltkontakte eines eingebauten Relais sind zur Frontplatte herausgebracht; das Relais wird bei Frequenzen bis zu 1 Hz durch den Rechteckwellenausgang betätigt und kann externe Vorrichtungen im Gleichlauf mit der Betriebsfrequenz ein- und ausschalten.

Die Möglichkeit, das Gerät im Einmal-Betrieb zu verwenden, erhöht seinen Wert bei Einsatz als Zeitmesser wesentlich. Das Zeitintervall kann durch einen Frontplatten-Schalter, einen fremderregten Impuls oder durch Schliessen eines externen Kontaktes ausgeführt werden.

Im TF 1382 werden die sinusförmigen Schwingungen auf ungewöhnliche Weise und zwar durch elektronische Synthese erzeugt. Die Grundwellenform ist eine Kippschwingung, die auch als eine der Ausgangswellenformen zur Verfügung steht. Durch Gleichrichtung der Kippschwingung entsteht eine Dreieckwellenform, die nicht zum Ausgang weitergeleitet wird. Die Dreieckschwingung wird in Zener-Dioden-Schaltung umgeformt, die eine Sinuswellenform abgibt. Die Rechteckwelle wird von der Dreieckwellenform durch bistabile Umschaltung abgewandelt.

EE 31 766 *für weitere Einzelheiten*

VOLTMETER MIT ENTNULLUNG

(Abbildung Seite 187)

Modell TF 1377 ist ein Kompensator-Spannungsmesser zur Messung absoluter Gleichspannungen bis zu 500 V und Spannungsänderungen der zu messenden Quelle, die bis zu 1 mV herunter abgelesen werden können. Es kann auch in üblicher Weise als Differentialspannungsmesser für den Bereich ±1 mV...±50 V benutzt werden.

Für die Kompensations- oder Entnullungs-Betriebsart wird die Quellenspannung gegen eine interne, potentiometergesteuerte Gleichspannungsquelle geschaltet, wobei für die Nullanzeige das Messgerät mit Mittel-Nullstellung benutzt wird. Die absolute Spannug der Quelle wird dann von der Digitalanzeige am Potentiometer abgelesen, und nachfolgende Spannungsänderungen können am Messgerät abgelesen werden. Dadurch können kleine Änderungen grosser Spannungen mit ungewöhnlichem Unterscheidungsvermögen einfach und genau gemessen werden, und komplizierte, unbequeme Anordnungen mit externen Batterien für die gegengeschaltete Spannung sind unnötig.

Für Differenzmessungen wird das Potentiometer abgeschaltet, und die unbekannten kleinen Spannungen werden direkt am Anzeigegerät abgelesen.

Das Gerät ermöglicht schnelle, genaue Messungen über einen grossen Gleichspannungsbereich im Labor, in der Fertigung und im Gelände. Sein Präzisionssystem für Wertzuwachsmessung ist besonders für Untersuchungen der Regelung und Konstanthaltung von Gleichspannungsquellen, Temperaturbeiwert-Messungen an Halbleitern, Widerständen usw. sowie für direkte Messung mit Dehnungsstreifen, Eichung von Widerstands-Wärmemessern und piezoelektrischen Gebern und zur Generatorregelung geeignet. Die Zweckdienlichkeit des Gerätes wird durch lieferbare Gleichrichtermessköpfe erhöht, die das Anwendungsgebiet auf Ton- und HF-Messungen ausdehnen.

EE 31 767 *für weitere Einzelheiten*

MORGAN CRUCIBLE CO. LTD

Battersea Church Road, London, S.W.11

HOHLLEITER-ABSCHLUSS

Diese Abschlusswiderstände wurden für Radarstationen entwickelt und ermöglichen Bereitschaftsbetrieb oder Test mit voller Leistung ohne nachweisbare Signalsausstrahlung und Störung anderer Stationen. Ungleich anderen für diesen Zweck bestimmten Materialien ist Siliziumkarbid der Grundstoff für "Termilode", das Energien in Kilowatts zerstreuen kann. Die Temperaturgrenze wird mehr durch Gasionisation im Hohlleiter als durch den Abschlusswerkstoff beeinflusst, der noch bei 1000°C zufriedenstellend arbeitet. Die verschiedenen gezeigten Modelle, deren Länge von Zentimetern bis zu Metern geht, sind für Luft- oder Flüssigkeitskühlung bestimmt. Zerstreuung bis zu 8 kW kann mit Wasserkühlung erreicht werden.

EE 31 768 *für weitere Einzelheiten*

MUIRHEAD & CO. LTD

Beckenham, Kent

AUTOMATISCHER REGISTRIER-WELLENANALYSATOR

(Abbildung Seite 188)

Dieses Gerät ist für die automatische Analyse und graphische Registrierung aller Arten von Geräusch- und Schwingungssignalen bestimmt, die ihm entweder direkt oder über Magnetbandaufzeichnungen zugeführt werden. Das Gerät gibt Amplituden-Frequenz-Analysen stetiger Signale und Amplituden-Frequenz-Zeit-Analysen nichtstetiger, mit Zeit sich ändernder Signale. Es arbeitet vollautomatisch über den ganzen Frequenzbereich von 10 Hz ... 19 kHz. Drei Selektionsgrade stehen zur Verfügung (1/3 Oktave, 5% und 1,5%), und in jedem Fall ist die prozentuale Bandbreite für alle Frequenzen konstant; das Unterscheidungsvermögen gegenüber unerwünschten Frequenzen ist hoch. Der Höchstfrequenzfehler auf dem vorgedruckten Registrierpapier ist nicht

grösser als 1%; der Eingangssignalbereich ist von 10 μV ... 300 V. Wenn der Eingangsabschwächer auf automatischen Betrieb geschaltet wird, kann ein dynamischer Amplitudenbereich bis zu 70 dB bewältigen.

EE 31 769 *für weitere Einzelheiten*

NASH & THOMPSON LTD

Hook Rise, Tolworth, Surrey

DIGITAL-ANZEIGE-MESSGERÄT

(Abbildung Seite 188)

Das neue Nashton Digitalvoltmeter wurde entwickelt, um die Lücke zwischen den üblichen Drehspulenanzeigen und den teuren Digitalvoltmetern auszufüllen und stellt einen leistungsfähigen und wirtschaftlichen Kompromiss dar. Die Anzeige-Drucktaste auf der Frontplatte schaltet eine selbstabgleichende Messbrücke ein, die elektromechanisch mit dem Anzeigeteil verbunden ist. Die üblichen Änderungen stellen sich in ein oder zwei Sekunden ein und der Zähler durchläuft seinen Bereich in 10 s. Das Gerät wird in zwei Baugruppen hergestellt und in das grosse Nashton-Gehäuse eingebaut. Der Anzeigebaustein ist links und der Messbaustein, d.i. das Voltmeter, rechts angeordnet. Die Anzeige besteht aus einem dreistelligen mechanischen Zähler, dessen Ziffern 6,35 mm hoch sind. Die Spannungsbereiche messen 1,00 ... 9,99; 10,0 ... 99,9 und 100 ... 999 V mit mehr als ±1,2% Genauigkeit des Istwertes ±1 Ziffer. Rechts einzubauende Messbausteine für Widerstand und Kapazität sind auch lieferbar. Das Messgerät kann ferngesteuert werden.

EE 31 770 *für weitere Einzelheiten*

G. V. PLANER LTD

Windmill Road, Sunbury-on-Thames, Middlesex

NANOSEKUNDEN-SCHALTZEITBESTIMMUNG

(Abbildung Seite 188)

Dieses Gerät wurde hauptsächlich zur Messung der Schaltzeit von Speichern wie z.B. der dünnen Legierungsfolien-Speicher entwickelt.

Der Impulsbereich überstreicht 2...200 ns und der Ausgang kann Schaltelemente treiben, deren Betrieb Ströme bis zu 13 A erfordert. Die Ausgangsspannung kann von 1 kV bis zu unter 1 V geregelt werden.

Der Prüfling wird in einen Durchlassmesskopf mit geeigneter Geberschleife eingesetzt. Der Generator ist so konstruiert, dass er positiv- oder negativgehende Impulse in veränderlichem Verhältnis zur gleichzeitigen Untersuchung des Schaltens und Nicht-Schaltens abgibt. Oszillografanschlüsse und ein Synchronimpuls sind vorgesehen. Der Netzanschluss ist für 230 V 50 Hz ausgelegt.

Das Gerät kann sowohl mit Oszillografen grosser Schreibgeschwindigkeit als auch Labormodellen benutzt werden.

EE 31 771 *für weitere Einzelheiten*

HYSTERESE-TESTER

(Abbildung Seite 188)

Dieses Gerät wurde für die Darstellung der Hysteresisschleife magnetischer Werkstoffe auf Elektronenstrahl-Oszillografen sowie zur Bestimmung der Remenanz und Koerzitivkraft entwickelt. Es ist zur Prüfung magnetischer Beschichtungen und besonders von Magnetbändern gedacht, kann aber auch zur Untersuchung von magnetischen Legierungen in Form dünner Folien, Streifen und Drähte eingesetzt werden.

Das Gerät besteht aus einem geeichten, geräuscharmen Verstärker und drei wahlweise verwendbaren Messköpfen mit entsprechenden Netzgeräten für die folgenden Bereiche:

(a) 50 ... 2000 Oersted. Der für Messungen von Magnettonbändern, Magnetstahl usw. geeignete Kopf hat einen Magnetkreis aus kornorientiertem Stahl. Die beiden Aufnahmespulen sind im gleichförmigen Feld positioniert.

(b) 0 ... 150 Oersted. Dieser Messkopf mit Helmholtz-Spulenanordnung ist zur Untersuchung flacher Folienspeicher bestimmt.

(c) 0 ... 10 Oersted. Der zur Messung ringförmiger Filme geeignete Messkopf hat aus je einer Windung bestehende Treib- und Abgreifspulen.

Das Gerät wird mit einem Standard-Oszillografen (z.B. Cossor Type 1049) benutzt.

EE 31 772 *für weitere Einzelheiten*

W. G. PYE & CO. LTD

Granta Works, Cambridge

PH-VERSTÄRKER FÜR DIE INDUSTRIE

(Abbildung Seite 188)

Die Schaltung dieses Gerätes besteht hauptsächlich aus einem Träger-Gleichspannungsverstärker mit Kapazitätsmodulator, einem Trägerverstärker und einem phasenempfindlichen Demodulator mit starker Gesamtgegenkopplung. Dadurch wird hohe Stabilität mit fast perfekter Linearität erreicht, während Netzspannungsschwankungen praktisch keine Änderung der Nullstellung und Empfindlichkeit hervorrufen. Da kein Eingangsstrom fliesst, können die unverwüstlichsten Glaselektroden benutzt werden, deren sehr hoher Widerstand keinen Linearitätsfehler hervorruft, was besonders für Messungen über einen grossen Temperaturbereich wichtig ist. Die Empfindlichkeit ist hoch (100 μA/pH), und deshalb können mehrere externe Schreiber, Anzeiger, Regler und Warnsysteme an denselben Verstärker angeschlossen und, wenn erforderlich, vom Verstärker entfernt eingebaut werden.

Das Gerät hat eine völlig automatische Temperaturkorrektur von 0 ... 100°C, und der pH-Messbereich des Standard-Gerätes überstreicht 2 ... 12.

EE 31 773 *für weitere Einzelheiten*

WECHSELSTROM-BRÜCKENVERSTÄRKER UND NETZGERÄTE

(Abbildung Seite 189)

Diese Geräte werden nach Konstruktionsunterlagen des Instituts der Königlichen Luftwaffe (R.A.E.) Farnborough hergestellt und verwenden zur Erzielung einer gedrungenen Konstruktion und Fertigungserleichterung gedruckte Schaltungen und Transistor-Bestückung.

Verstärker Type IT 1-13-51 ist für induktive Gegentakt-Beschleunigungsgeber bestimmt und enthält Integrations-Schaltungen, die für die Weganzeige auf Oszillografen, Galvanometern oder Aufzeichnung mittels FM-Magnetbandgeräten im Bereich 5 ... 100 Hz erforderlich sind.

Verstärker Type IT 1-12-51 wurde für Dehnungsmessstreifen entwickelt. Die Brückenwiderstände sind hochstabil und haben abgestimmte Temperaturbeiwerte. Die gemessenen Wegänderungen können auch mit diesem Gerät mittels Oszillografen, Galvanometern oder FM-Magnetbandgeräten über einen Bereich von 0 ... 1 kHz aufgenommen werden.

Das Netzgerät Type IT 1-13-52 enthält die Stromversorgung für sechs Verstärker derselben oder beider Verstärker-Typen und erzeugt gleichzeitig das Trägerfrequenzsignal zur Erregung der Geber-Brücken und Demodulation der sechs Verstärker. Die Trägerfrequenz kann durch Umlegung einer internen Verbindung auf 2 kHz oder 3 kHz eingestellt werden.

Die Geräte werden vom normalen Flugzeugbordnetz mit 27-29 V Gleichspannung betrieben. Anzeigemessgeräte sind für beide Verstärker-Typen lieferbar.

EE 31 774 *für weitere Einzelheiten*

RACAL INSTRUMENTS LTD

Western Road, Bracknell, Berkshire

DIGITAL-FREQUENZMESSER

(Abbildung Seite 189)

Im SA.505 sind die neusten Transistor-Fortschritte in einem kompakten, abgeschlossenen Gerät vereinigt, das für alle Laborarbeiten auf den Gebieten der Frequenz-, Zeitdauer- und Intervallmessungen geeignet ist.

Eine siebenstellige, einreihige Projektionsvorrichtung zeigt laufend gemessene Werte an. Das Gerät ist für direkte Frequenzmessungen von sinusförmigen und Impuls-Signalen von 0 ... 10 MHz und für Zeitintervallmessungen zwischen zwei aufeinanderfolgenden positiv- oder

negativ-gehenden Impulsen im Bereich von 0,1 μs ... 10^4s ausgelegt. Zeitdauermessungen können auch über 1, 10 und 100 Perioden einer unbekannten Frequenz mit einer Genauigkeit von $1 \cdot 10^{-6}$ durchgeführt werden.

Die Messgenauigkeit für Frequenzen ist ± Zählimpuls ± der Konstanz des eingebauten Quarzes, die $1 \cdot 10^{-7}$ ist. Anschlüsse für Betrieb eines externen Frequenznormals für 100 kHz oder 1 MHz sind vorgesehen.

Die Digitaldaten stehen im Gerät auch in Form schliessender Relais-Kontakte zur Verfügung und können entweder für direkte Fernanzeige entnommen werden oder über den Parallel-Serien-Umsetzer Type S.A.138 ein Addo-X-Druckwerk betätigen.

EE 31 775 *für weitere Einzelheiten*

W. H. SANDERS (ELECTRONICS) LTD

Gunnels Wood Road, Stevenage, Hertfordshire

VIELLOCH-RICHTKOPPLER

(Abbildung Seite 189)

Diese Vielfach-Richtkoppler sind für Hohlleitergrössen 12, 14, 15, 16, 18 und 22 lieferbar und überstreichen das gesamte 3,95 ... 40 GHz-Band.

Die Koppler haben runde Löcher, die als Kopplungselemente zwischen den Breitseiten zweier Hohlleiter dienen und nach Tschebyscheff angeordnet sind. Der Hauptvorteil dieser Löcher ist, dass die Richtwirkung äusserst breit gemacht werden kann, ohne sich an den Bandgrenzen wie im Falle der binomischen Anordnungen zu verschlechtern. Dadurch wird es möglich, Richtkoppler herzustellen, deren Richtwirkung über den gesamten Frequenzbereich grösser als 40 dB ist. Sie haben eine Kopplungsfrequenzempfindlichkeit von ±0,5 dB und eine mittlere Kopplungsgenauigkeit von ±0,3 dB.

EE 31 776 *für weitere Einzelheiten*

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Connaught House, Aldwych, London, W.C.2

EPITAXISCHE TRANSISTOREN

Epitaxie ist ein Verfahren, in dem eine Schicht aus Halbleitermaterial durch Niederschlag eines Gases, z.B. Germaniumdijod, bei hohen Temperaturen auf ein Keimkristall niedrigerer Temperatur aufgebracht wird. Das niedergeschlagene Material hat dieselbe Kristallorientierung wie der Keim.

In den meisten diffundierten Transistoren muss das Material, das die Kollektorzone bildet, einen hohen spezifischen Widerstand haben, um eine hohe Kollektor - Durchschlagsfestigkeit zu erreichen. Bisher waren der Verminderung der Kollektorzonenstärke durch mechanische Probleme Grenzen gesetzt, da es sehr schwierig ist, aus sehr dünnen Scheibchen hergestellte Transistoren zu handhaben. Eine hohe Durchschlagsspannung ist daher nicht mit einem guten Verlauf der unteren Kennlinie d.h. niedrigem Kollektor-Serienwiderstand) vereinbar.

In epitaxischen Transistoren wird eine sehr dünne Schicht eines Materials mit hohem spezifischem Widerstand auf eine Seite eines Materialscheibchens niedrigen spezifischen Widerstandes niedergeschlagen. Der Transistor wird dann in bekannter Weise durch Festkörperdiffusion in ein Material mit hohem spezifischem Widerstand umgewandelt. Das Material mit niedrigem spezifischem Widerstand (der Keim) wirkt nur einfach als Träger des Transistors und gibt ihm mechanische Festigkeit.

Der so entstandene Transistor hat einen besseren Verlauf der unteren Kennlinie, und die Anwendung der Epitaxie gibt grössere Entwicklungsflexibilität, da einige der Transistor-Parameter nicht mehr so stark voneinander abhängig sind. Dadurch können schnellere Schaltzeiten und niedrigere Ausgangskapazitäten erzielt werden.

EE 31 777 *für weitere Einzelheiten*

VENNER ELECTRONICS LTD

Kingston By-Pass, New Malden, Surrey

DIGITAL-VOLT-OHMMETER

(Abbildung Seite 189)

Dieses Gerät kann Gleich- oder Wechselspannungen von 1 mV ... 1,1 kV und Widerstände bis zu 1,1 MΩ messen.

Die Werte werden deutlich durch vier neuartige einzeilige Projektionsanzeiger mit automatischer Polaritätsanzeige dargestellt und können durch direkte Kopplung an ein Venner-Druckwerk und/oder ein Lochstanzen-Steuergerät registriert werden.

Weder Schrittschalter noch Relais werden in dem Instrument benutzt, das aus transistorisierten Einsteckstufen besteht. Es gibt stetige Anzeigen bei Eingangsschwankungen und die Bedienung ist einfach.

EE 31 778 *für weitere Einzelheiten*

Zusammenfassung der wichtigsten Beiträge

Kaltkathodenröhren-Schaltungen für die Automation von R. S. Sidorowicz

Zusammenfassung des Beitrages auf Seite 138-143

Die folgenden Bausteine für Kaltkathodenröhren-Schaltungen werden beschrieben: (1) vier verschiedene Impulsverstärker; (2) vier verschiedene Verzögerungsschaltungen oder einseitige Multivibratoren; (3) drei binäre Zähler, drei Ringzähler und ein umsteuerbarer oder in beiden Richtungen arbeitender Zähler; (4) drei verschiedene logische Oder-Schaltungen und zwei logische Und-Schaltungen; (5) eine Verschiebematrix oder ein Verschieberegister; (6) sechs verschiedene Oszillatoren und Multivibratoren; (7) eine Treiberschaltung für eine Digitalanzeigeröhre. Die Schaltungen benutzen Widerstände, Kondensatoren und drei Kaltkathoden-Trioden (XC 18, XC 23 und XC 24). Als Quelle der konstanten Vor- oder Zündspannung findet die Kaltkathoden-Kleinstabilisierungsröhre XC 12T Verwendung. Alle Schaltungsbausteine sind selbstgehend und werden nach Ablauf des Arbeitstaktes automatisch in die Ruhestellung zurückgeführt. Für die Entwicklung

industrieller Automationssysteme bilden diese Bausteine eine folgerichtige Kaltkathodenröhren-Schaltungsserie. Drei praktische Beispiele werden gegeben, die zeigen, in welcher Weise die Bausteine zur Konstruktion verhältnismässig komplexer Systeme kombiniert werden können: ein elektronischer Vorwahl-Impulsgeber, ein programmierter Vorwahl-Zähler und eine elektronische Prüfvorrichtung. In den aufgebauten Systemen werden mechanische Kontaktgeber, Schalter und Photowiderstände als Eingangsgeber für die Kaltkathodenröhren-Schaltungen eingesetzt; in den Ausgängen werden normalerweise elektromagnetische Relais verwendet. Zum Betrieb der Systeme ist ein stabilisiertes Netzgerät für +180 V erforderlich. Die Taktfrequenz kann 100 Hz übersteigen.

Ein schneller Analog-Digitalwandler von M. Winterbottom und J. S. Walters

Zusammenfassung des Beitrages auf Seite 144-149

Bei der Verarbeitung grosser Datenmengen in elektronischen Geräten steht in vielen Fällen die Information an verschiedenen Stellen des Systems sowohl in analoger als auch in digitaler Form zur Verfügung. In solchen Fällen ist es erforderlich, die Information von der analogen in die digitale Form umzuwandeln.

Ein schneller Analog-Digitalwandler wird beschrieben, der pro Sekunde 55 000 Analogspannungen in einen 8-Bit-Binärcode umwandeln kann. Das Gerät benutzt Transistoren als aktive Elemente.

Eine neuartige Digital-Uhr von A. Russell

Zusammenfassung des Beitrages auf Seite 150-154

Konstruktion und Arbeitsweise einer neuartigen Digital-Uhr wird beschrieben, die Monat, Tag, Stunde, Minute, Nummer des Versuches und des Tests auf beleuchteten, einzeiligen Sichtanzeigen registriert. Die gesamte Information einschliesslich des Jahres steht als Serienablesung zum Stanzen von Lochstreifen oder Ausschreiben auf magnetspulenbetätigten elektrischen Schreibmaschinen zur Verfügung. Die verwendete Rückstellmethode ermöglicht schnelle Einstellung neuer Verknüpfungen. Das vorhandene Labor-Frequenznormal liefert Impulse mit genauem Abstand, die den Kalenderteil treiben, der damit als Monitor für die langfristige Genauigkeit dieses Frequenznormals dient.

Ein vielseitiger Zwangsfunktionsgeber von J. Morrison

Zusammenfassung des Beitrages auf Seite 155-159

Der Beitrag beschreibt einen Zwangsfunktionsgeber für Analogrechner, der Sinus–, Rechteckwellen–, Dreieck–, Anstieg–, Sprung– oder Impulsfunktionen mit einer Genauigkeit von 1/4% des wahren Frequenz– und Amplitudenmassstabs abgibt. Der Frequenzbereich überstreicht 0,001 Hz bis 100 Hz und kann vom Rechner aus oder extern gesteuert werden.

Kalkulationsdiagramm für Antennen mit Parabolspiegeln von C. O. Titley

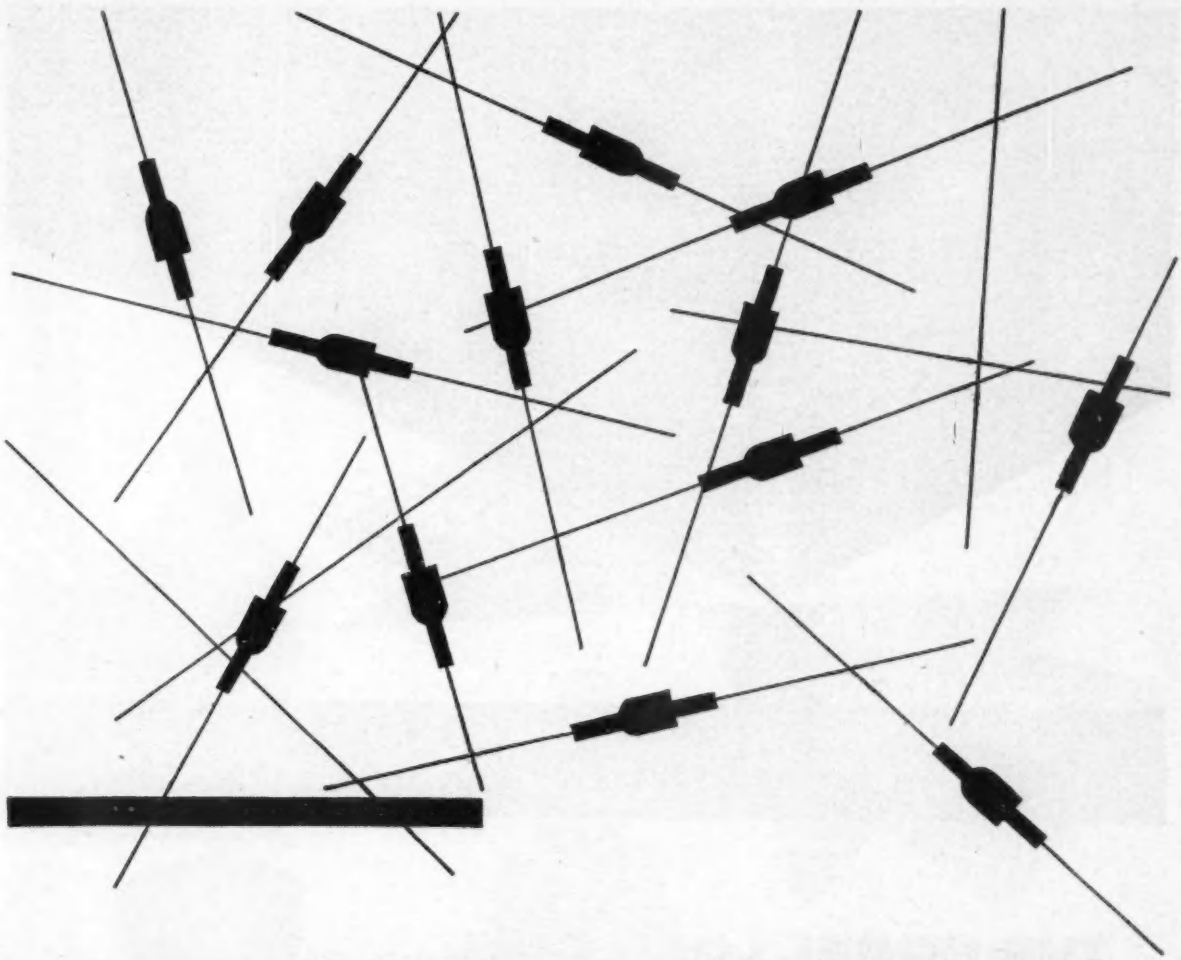
Zusammenfassung des Beitrages auf Seite 162-163

Die innere Oberfläche eines Parabolspiegels wird durch Drehung einer Parabel um ihre Symmetrieachse erzeugt. Solch ein Spiegel hat die einzigartige Eigenschaft, bei gleichmässiger Beleuchtung von einer punktförmigen Quelle im Brennpunkt Strahlungen hervorzurufen, die über die gesamte Öffnungsebene phasengleich sind. Deshalb finden Parabolspiegel in Radioverbindungen und Optik weitgehende Verwendung. Das hier wiedergegebene Diagramm wurde als Kalkulationshilfe zur Entwicklung von Reflektoren für Radioantennen angefertigt.

Bandfilterketten mit piezoelektrischen Keramikscheiben von R. C. V. Macario

Zusammenfassung des Beitrages auf Seite 171-177

Piezoelektrische keramische Massen mit hohem elektromechanischem Kupplungsmodul und mittleren Q-Werten können in Form kleiner, kreisförmiger, in radialer Weise schwingender Scheiben mit oder ohne Kondensatoren interessante Bandfilterketten bilden. In diesem Beitrag werden die Daten für Konstruktionsmöglichkeiten einer Anzahl von Netzwerken untersucht, in Kurvenform dargestellt und genaue Konstruktionsdaten in Tabellenform gegeben. Sie stützen sich auf die Spiegelparametertheorie, und die Berechtigung für diese Annahme wird durch Vergleich mit gemessenen Filterfrequenzgängen nachgewiesen. Die erzielbaren Bereiche für Mittelfrequenz, Bandbreite und Spiegelimpedanz werden diskutiert.



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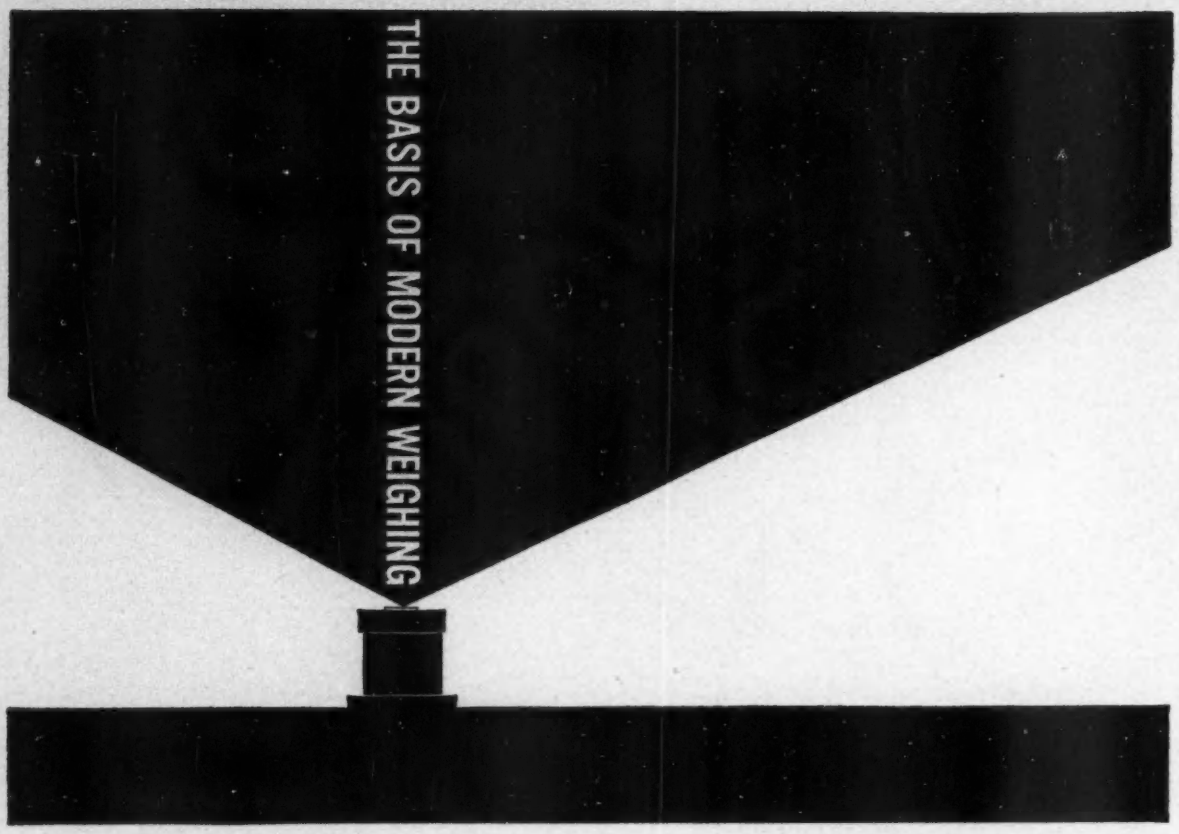
RECTIFIER DIVISION: EDINBURGH WAY · HARLOW · ESSEX · HARLOW 26811. Extn. 247

EE 31 123 *for further details*



THE NOBEL LOAD CELL

A superior weighing device of first class constructional design employing unbonded strain gauges, giving high zero stability and excellent overload features.

Associated equipment of equally high standard provides facilities for remote control, visual display of output or permanent records in the form of print, punched card or tape from any number of cells.

In many cases existing beam and balance weighers, constant rate feeders and similar devices can be extensively controlled by means of our "Rota-weigh", "Multi-Batch" or special controllers specifically designed to meet customer's requirements. If you are considering an entirely new weighing-system or altering your existing plant, talk it over with us — our experience may be what you are looking for.

- **Accuracy — better than 0.25% of f.s.d.**
- **High zero stability.**
- **High long term stability on load.**
- **Good overload facilities.**
- **Fail safe in event of gross overload.**
- **Oil filled and hermetically sealed.**
- **Corrosion resistant**
- **5 standard types to weigh up to 50,000 lbs.**

Enquiries should be addressed to:—

BENDIX ERICSSON U.K. LTD.

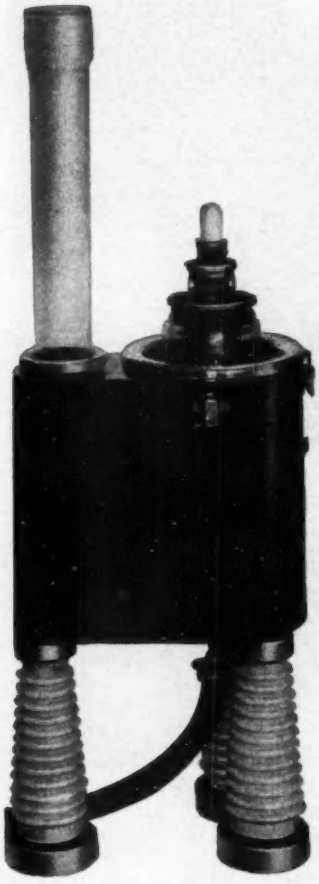
HIGH CHURCH STREET · NEW BASFORD · NOTTINGHAM · Telephone: Nottingham 75115

(FORMERLY ERICSSON INSTRUMENT DIVISION)

'Q' type

STC Valves

SPECIALLY DESIGNED for R.F. HEATING



'Z' type in boiler

'J' type

- *Generous safety factors*
- *Rugged*
- *High efficiency*
- *Heavy gauge anodes*
- *Operating frequencies up to 100 Mc/s*
- *Available as*
  - *Forced Air Cooled (J Type)*
  - *Water Cooled (Q Type)*
  - *Vapour Cooled (Z Type)*
- *Anode dissipations from 6 to 24 kW*
- *Ancillary equipment available*

STC COMPONENTS GROUP

60/2MS

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London W.C.2

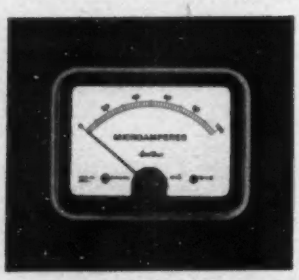
VALVE DIVISION: FOOTSCRAY · SIDCUP · KENT

Instrumentation in Television

Ernest Turner instrumentation at the BBC Television transmitter, London.

Ernest Turner electrical measuring instruments represent the highest standards of design accuracy and workmanship. Clean lines, easily-read scales and attractive appearance combine with technical quality to present precision and industrial grade instrumentation in a wide variety of types, ranges and dimensions.

Full details of all Ernest Turner instruments are given in Catalogue No. 85, available upon request.



Ernest Turner

ELECTRICAL INSTRUMENTS LTD

HIGH WYCOMBE · BUCKINGHAMSHIRE · ENGLAND

STC announce

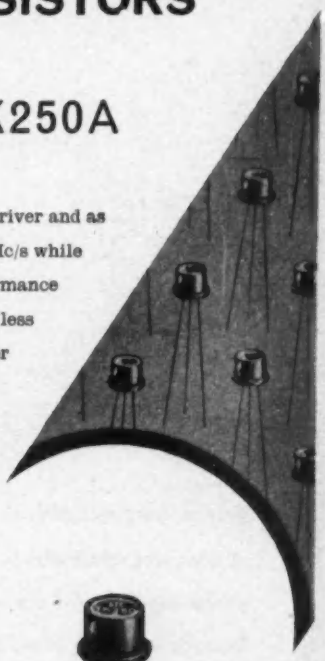
SILICON DIFFUSED n-p-n HIGH FREQUENCY TRANSISTORS

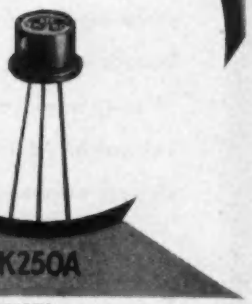
— TO JEDEC OUTLINES

Types TK200A & TK250A

The TK200A has outstanding characteristics as a coredriver and as a power oscillator working at frequencies up to 10Mc/s while its companion, the TK250A, enables maximum performance to be obtained where the power requirements are less demanding, e.g. in the driver stage of a power oscillator and in high-current switching. Make a note of the following characteristics — essential to the new generation of high-speed logic circuits.

Type TK200A





Type TK250A

	Type TK200A	Type TK250A
Characteristics	f_T Common emitter gain-frequency product at I_C = 20mA, V_{CE} = 9V, f = 20Mc/s — 50 Mc/s min	f_T Common emitter gain-frequency product at I_C = 20mA, V_{CE} = 9V, f = 20Mc/s — 50 Mc/s min
	V_{CES} Collector-to-emitter saturation voltage at I_C = 200mA, I_B = 25mA — 2·5V max	V_{CES} Collector-to-emitter saturation voltage at I_C = 100mA, I_B = 12·5mA — 1·6V max
	I_{CBO} Collector-to-base leakage current at V_{CB} = 9V, I_E = O — 1μA max	I_{CBO} Collector-to-base leakage current at V_{CB} = 9V, I_E = O — 1μA max
Outline	JEDEC TO–3	JEDEC TO–9
Ratings	$V_{CB\,max}$ with emitter open circuited or reversed biased — 40V	$V_{CB\,max}$ with emitter open circuited or reverse biased — 40V
	$V_{CE\,max}$ with base-emitter junction reverse biased — 40V	$V_{CE\,max}$ with base emitter junction reverse biased — 40V
	$V_{CE\,max}$ with base open circuited — 20V	$V_{CE\,max}$ with base open circuited — 20V
	$V_{BE\,max}$ reverse direction — 6V	$V_{BE\,max}$ reverse direction — 6V
	$I_{C\,max}$ — 0·5A	$I_{C\,max}$ — 0·25A
	Power dissipation in a heat sink — 10W max	Junction temperature — 150°C max
	Junction temperature — 150°C max	Storage temperature — 150°C max
	Storage temperature — 150°C max	

For further information write to:

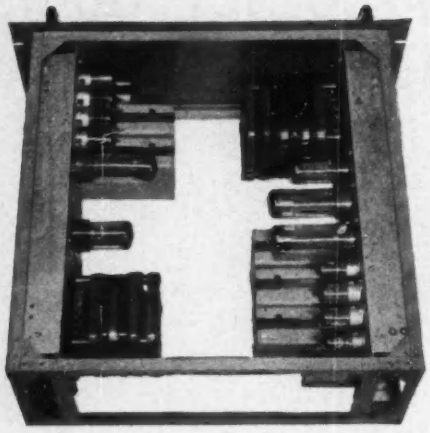
Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London W.C.2

TRANSISTOR DIVISION: · FOOTSCRAY · SIDCUP · KENT

6.7MA

regulated - well ventilated - power supplies



Two of model V300/200 mounted in one suitable frame measuring 17¼" × 17¼" × 7". This shows one of many methods of mounting these units

Brandenburg recognize the importance of adequate ventilation in regulated unit power supplies; and the improved design for rack mounting of the new Brandenburg 'V' range introduces a wide centre ventilation. Additionally, there is easier access to all components

all models—types V and HV

polarity	reversible
effective resistance	0·1 ohm
stability	against + or −10% mains change: 0·02%
ripple	less than 2mV
input	200/250 volts, 50 cycles
output a.c.	100 and 200 mA models: 4 × 6·3V, 1·5A. 350 and 500 mA models: 2 × 6·3V, 5A. All can be paralleled
dimensions	100 and 200 mA models: 15½" × 5½" × 6½" high. 350 mA models: 15½" × 7½" × 7½" high. 500 mA models: two chassis, each 15½" × 5½" × 6½" high. Flanged open chassis, with frames available for converting all models to front panel mounting

All prices quoted are for U.K. only

Model	D.C. output		Prices	Model	D.C. output		Prices	High current models	D.C. output		Prices
	Volts	m/Amps			Volts	m/Amps			Volts	Amps	
V200/100	200	100		V200/350	200	350					
V250/100	250	100	£37 10 0	V250/350	250	350	£64 0 0	HV250/1A	250	1	£140 0 0
V300/100	300	100	ex-works	V300/350	300	350	ex-works	HV300/1A	300	1	ex-works
V350/100	350	100		V350/350	350	350		HV350/1A	350	1	
V200/200	200	200		V200/500	200	500					
V250/200	250	200		V250/500	250	500	£80 0 0	HV250/2A	250	2	£230 0 0
V300/200	300	200	£48 10 0	V300/500	300	500	ex-works	HV300/2A	300	2	ex-works
V350/200	350	200	ex-works	V350/500	350	500		HV350/2A	350	2	
V400/150	400	150									

complete with 19" front panel and assembly

Brochure on request: for further specifications of the Brandenburg 'V' range please write for brochure

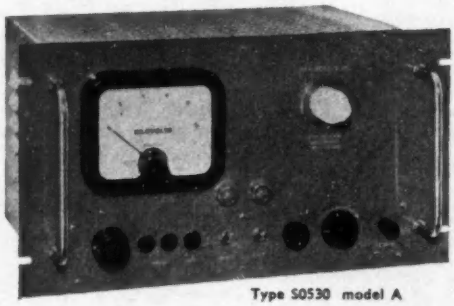
BRANDENBURG LIMITED

139 Sanderstead Road, South Croydon, Surrey. SANderstead 3555/6

Export enquiries to: Applied Research (Instruments) Ltd. Emefco House, Reigate, Surrey, England

high voltage regulated power supplies —standard models up to 100 kV.

5, 10, 20 and 30 kilovolt regulated supply



Type S0530 model A

All prices quoted are for U.K. only

Type S0530

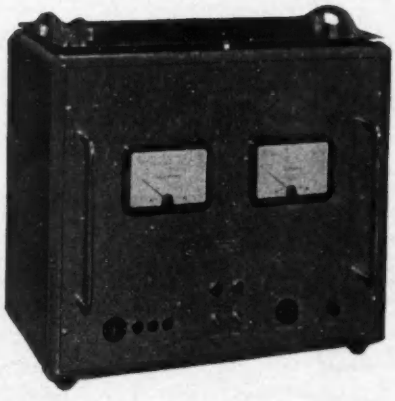
output	1 to 10 kV at 2mA. Model A 2 to 20 kV at 1 mA. Model B 3 to 30 kV at ½ mA. Model C 500 V to 5 kV at 2 mA. Model D
input	200/250 volts, 50 cycles
polarity	positive or negative grounded available
regulation	against full load: better than 0.5%. Against mains variations of plus or minus 7%, better than 1%

- 5" Ernest Turner movement
- current metering jack
- standard 19" x 10½" P.O. panel
- for rack mounting or bench use

£135 ex-works

Models A, B and C can be supplied with reversible output polarity at £165

50 kilovolt regulated supply



Type MR50R

Type MR50R

output	5 kV to 50 kV at 1 mA
input	200/250 volts
polarity	reversible
regulation	against full load: better than 1% Against mains variations: +5%,—5%, better than 1%
dimensions	W: 24" H:23" D: 15"

£245 ex-works

100 kilovolt regulated power supply

Type MR100R—3 models

output current	0.5 mA. Model MR100R/500 1 mA. Model MR100R/1
output voltage	10 to 100 kilovolts, continuously variable
polarity	reversible
ripple	0.1%
regulation	no load to full load: better than 1%. Against mains variations of plus or minus 7%, better than 1%
input	200/250 volts, 50 cycles
metering	output voltage and current metered by 5" Ernest Turner, Model 605

Brochure on request : for further specifications of this Brandenburg range of standard high voltage equipment, please write for brochure.

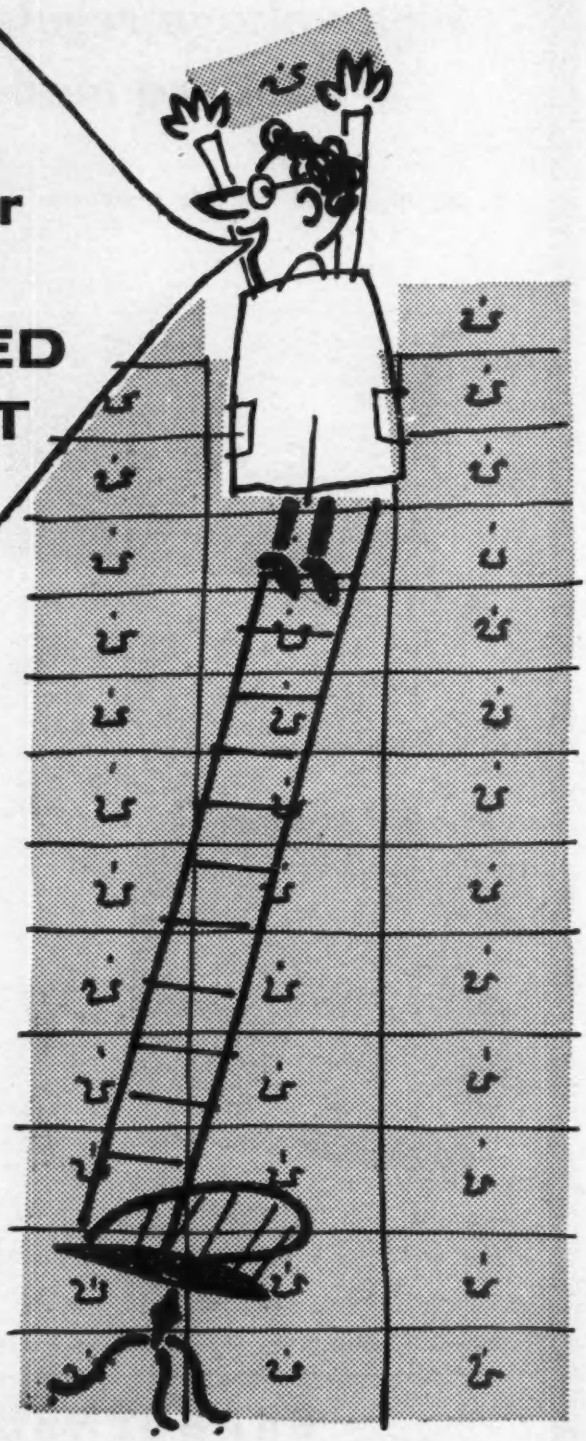
BRANDENBURG LIMITED

139 Sanderstead Road, South Croydon, Surrey. SANderstead 3555/6

Export enquiries to: Applied Research (Instruments) Ltd. Emefco House, Reigate, Surrey, England

EE 31 129 *for further details*

we have greatly EXTENDED our range of PTFE COVERED INSTRUMENT WIRE and SLEEVING



Our range of PTFE covered instrument wire now includes Type A and Type B (to Ministry of Aviation Specification EL 1930, Issue 3).
Type A is lapped and Type B is extruded. With both methods of covering we employ precision techniques and both types of wire are guaranteed concentric. We hold full Type Approval for their manufacture.
PTFE sleeving will solve your space, weight, temperature and electrical problems. It is available in sizes from 0.013 in. internal diameter with wall thicknesses from 0.006 in.
PTFE covered instrument wire has the following advantages which make it ideal for wiring a wide variety of specialised electronic equipment.

* *High dielectric constant permits use of thinner sleeving to save space and weight*
* *Extreme resistance to corrosion*
* *Practically frictionless*
* *Wide working temperature range*
* 11 *single and over* 19 *bi-colours*
* *Delivery from stock*

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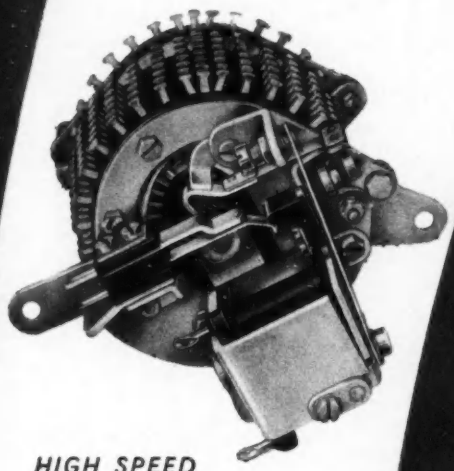
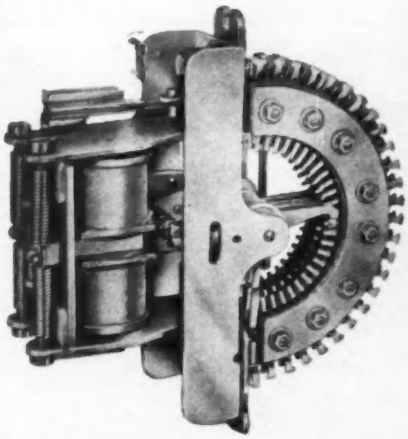
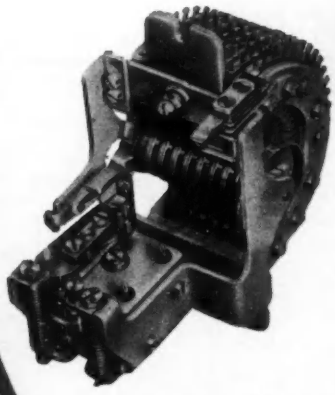


HIGH SPEED
MINIATURE
UNISELECTORS

TENSION
GAUGE



BOTHWAY
UNISELECTORS



HEAVY DUTY
UNISELECTORS

G.E.C. Uniselectors

EE 31131 *for further details*

STANDARD L. T. POWER SUPPLY RECTIFIERS—FULL WAVE BRIDGE

CODE NO.	Max.* A.C. INPUT V rms	D.C. OUTPUT		PLATE DIMENSION		MOUNTING DIMENSION inches	TERMINAL EXTENSION inches	FIXING STUD SIZE
		VOLTS	AMPS	HEIGHT	WIDTH			
C1B1SDBED	22	16	1.0	1½	1½	1½	⅜	3BA
L1B1SDBED	22	16	2.0	2	2	1⅞	⅝	¼W
D1B1SDBGD	26	20	5.0	3	3	2½	⅝	⅜W
D1B2SDBGD	26	20	10.0	3	3	4⅛	⅝	⅜W
A1B1SDBKD	33	26	0.4	1	1	1⅛	⅜	3BA
L1B1SDBKD	33	26	2.0	2	2	1⅞	⅝	¼W
C1B3SDBKD	33	26	3.0	1½	1½	3⅛	⅜	3BA
D1B1SDBKD	33	26	5.0	3	3	2½	⅝	⅜W
A2B1SDBKD	66	52	0.4	1	1	2⅛	⅜	3BA
L2B1SDBKD	66	52	2.0	2	2	3	⅝	¼W
D2B1SDBKD	66	52	5.0	3	3	4⅛	⅝	⅜W

* MAX. VOLTAGE USED AT 10% BELOW TO ALLOW FOR INPUT VARIATION

SELENIUM

RECTIFIER STACKS

RADIO AND TELEVISION RECTIFIERS—HALF WAVE

CODE NO.	Max. A.C. INPUT V rms	CURRENT RATING mA	MAX. PIV	PLATE DIMENSION		LENGTH over stud inches	TERMINAL EXTENSION inches	MINIMUM SERIES RESISTOR ohms
				HEIGHT	WIDTH			
RS—050E	130	50	380	21/32	21/32	¾	13/32	47
RS—065E	130	65	380	1	1	¾	13/32	22
RS—150E	130	150	380	1.2	1.2	1	13/32	15
G59—0840	250	250	700	1.2	1.2	5	13/32	5
G59—0841*	250	300	700	1.2	1.2	6	13/32	5

*HALF WAVE RATING. CENTRE TERMINAL PROVIDED FOR DOUBLER CONNECTION

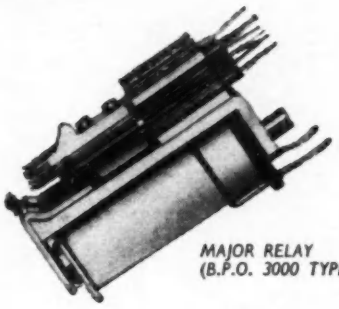
ASK FOR BULLETIN SR2006
FOR OUR FULL RANGE OF SELENIUM RECTIFIERS REQUEST BULLETIN SR 2005A

INTERNATIONAL RECTIFIER COMPANY

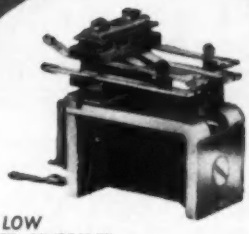
(GREAT BRITAIN) LIMITED · OXTED · SURREY · Oxted 3215

Associate Company of International Rectifier Corporation, U.S.A. and The Metal Industries Group, Great Britain.

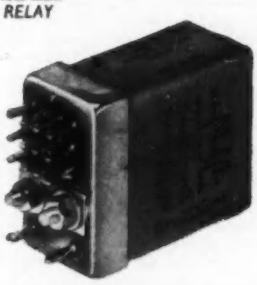
G&G



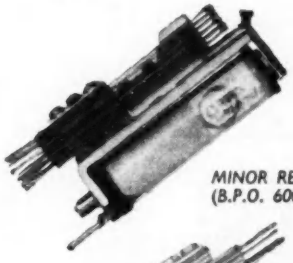
MAJOR RELAY
(B.P.O. 3000 TYPE)



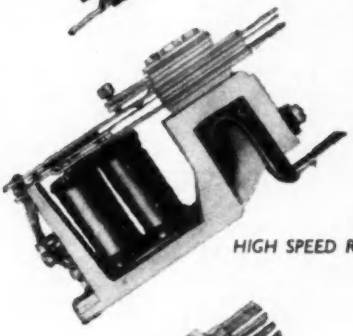
LOW LOSS, LOW
CAPACITANCE, UNSEALED
TYPE MINIATURE RELAY



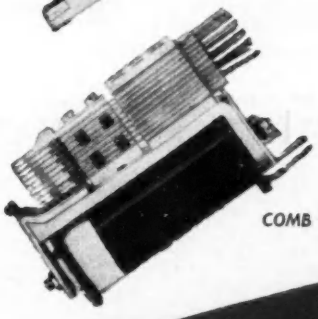
MINIATURE SEALED RELAY



MINOR RELAY
(B.P.O. 600 TYPE)



HIGH SPEED RELAY



COMB RELAY

G.E.C.

Relays

TENSION
GAUGE

For full details of all G.E.C. Apparatus for Stepping and Controlling Applications please write to:—

THE GENERAL ELECTRIC COMPANY LTD. OF ENGLAND
TELEPHONE WORKS · COVENTRY · ENGLAND
Works at: Coventry · London · Middlesbrough · Portsmouth

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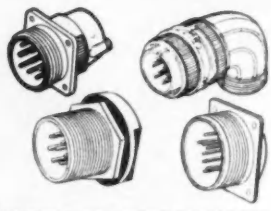
ELECTRICAL CONNECTORS (PLUGS AND SOCKETS) for EVERY conceivable application

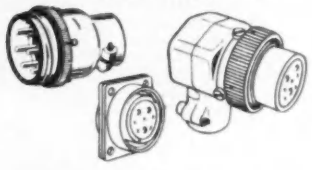
AIRCRAFT ENGINE, INSTRUMENTATION, INDUSTRIAL AND GENERAL ELECTRONICS APPLICATIONS—THE MS SERIES CONFORMING TO MIL-C-5015D

The MS and MS related series can provide connectors with the following characteristics:— High-temperature, vibration-proof, lightweight, environmental, radiation-resistant, potting, bulkhead, hermetically sealed, splashproof, waterproof. They are available with from 1 to 100 contacts, 15 different insert diameters from ½" to 2½", over 260 contact layouts, 6 shell styles, current rating from 10 to 200 amps, working voltages from 200 to 50,000 volts AC. Contacts are precision machined from high quality copper, silver plated to ensure low contact resistance. All other components are manufactured to extremely high precision standards and provide the utmost in reliability.



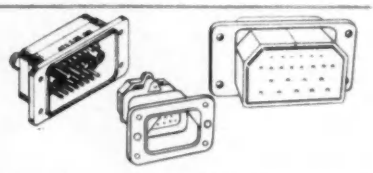
GENERAL CIRCUITRY AND INDUSTRIAL APPLICATIONS—THE K AND RK SERIES

A general purpose, rugged durable range, offering:— Acme coarse thread coupling; conduit or cable clamp entry, lightweight construction. Available with from 1 to 110 contacts, including coaxials, in eight different insert diameters from ½" to 2½". There are 7 basic shell styles accommodating more than 220 insert arrangements with current ratings of from 10 to 200 amps and a variety of voltage capacities. Contacts are brass, silver plated; Insulators of high quality phenolic, melamine or formica. Shells are cadmium plated aluminium alloy. Hermetically sealed types available with steel shells. An audio/video series is available in this range.



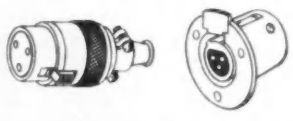
UNIT-PLUG-IN RACK/PANEL APPLICATIONS:—THE D AND DP SERIES

This rectangular range of connectors permit rapid disconnection, interchange, replacement, testing and inspection of assemblies and sub-assemblies. Designed for "rack and panel" applications, both mating halves can be rigidly mounted, or one can be cord connected if required. There is a vast range available including hermetically sealed, pressurised and environmental types. 2 to 224 contacts can be provided in rectangular inserts ranging in size from ⅞" x ⅝" up to 2½" x 4½", with a great variety of current and voltage ratings.



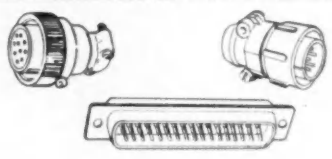
AUDIO/VIDEO AND LOW LEVEL CIRCUIT APPLICATIONS

Six different ranges are available which can primarily be identified by their latch-lock coupling mechanism, a device which permits rapid positive engagement whilst preventing accidental disconnection of trailing cables. Rugged cylindrical shells permit use under arduous service conditions. 1 to 18 contacts, with current ratings from 10 to 30 amps are provided in insert diameters 1" or smaller.



MINIATURE AND SUBMINIATURE SERIES

These ranges of connectors are already extensive but are continually expanding due to current weight-space limitations of modern flight. Designed for amplifiers, miniature indicators, computor circuits, telemetering equipment and general instrumentation. The majority of contacts are 5 amp, gold plated copper. From 3 to 54 contacts are obtainable with miniature coaxials in some series. Rectangular or circular types. *Maximum* insert sizes are ⅝" x 1 7/16" for rectangular series and 1" diameter for circular. Hermetically sealed and environmental types available.



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Available in a wide range of Series and types including subminiatures, MB-SM, HN, N, BNC. The latest development is the new aluminium series of R.F. connectors and adapters designed for use with semi-flexible aluminium sheathed cables, where weight saving is a critical design criteria. Currently available are types TNC, N, C, SC, LT and LC plugs and jacks.

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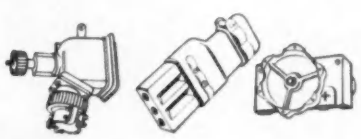

For additional information on any of the series referred to above or if you have any specific connector problems write, quoting EE to:—

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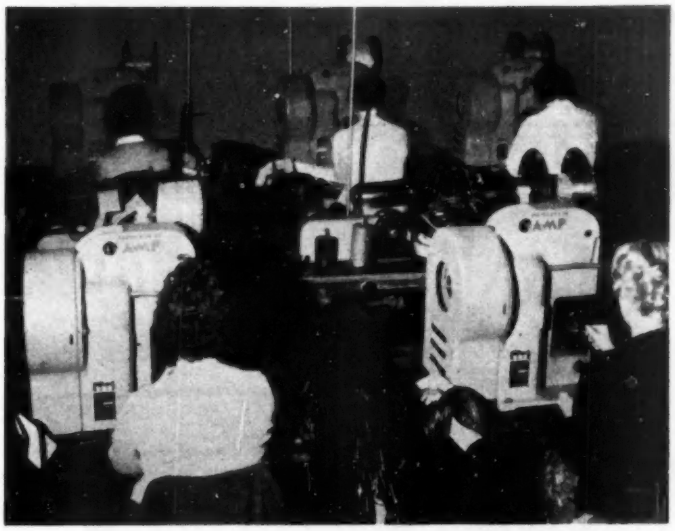

The above illustration shows a battery of Automachines applying spade terminals to telephone cords

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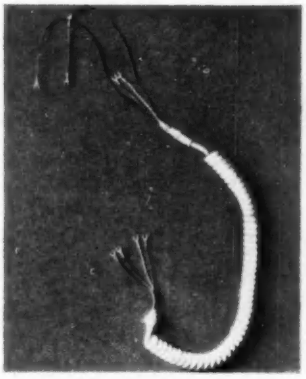
Close up of Automachine in operation.



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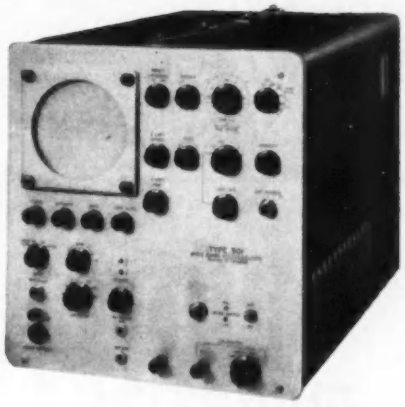

TYPE 301
High Speed
D.C.—40 Mc/s
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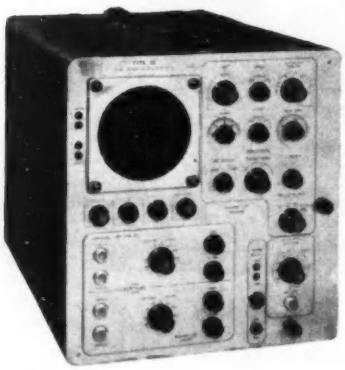

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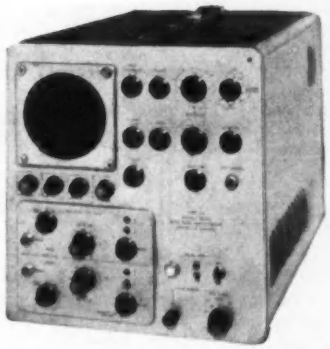

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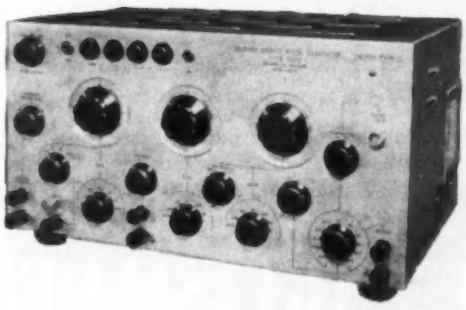

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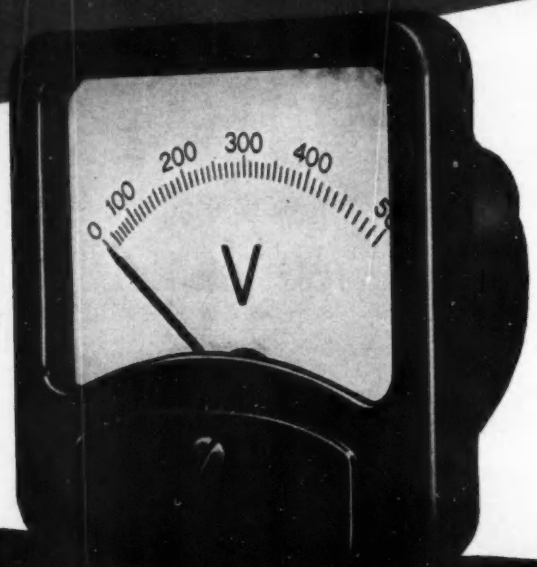

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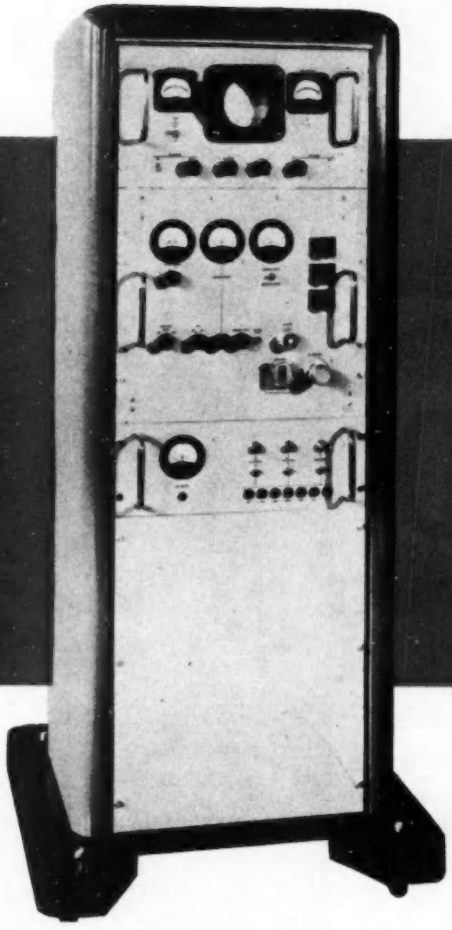

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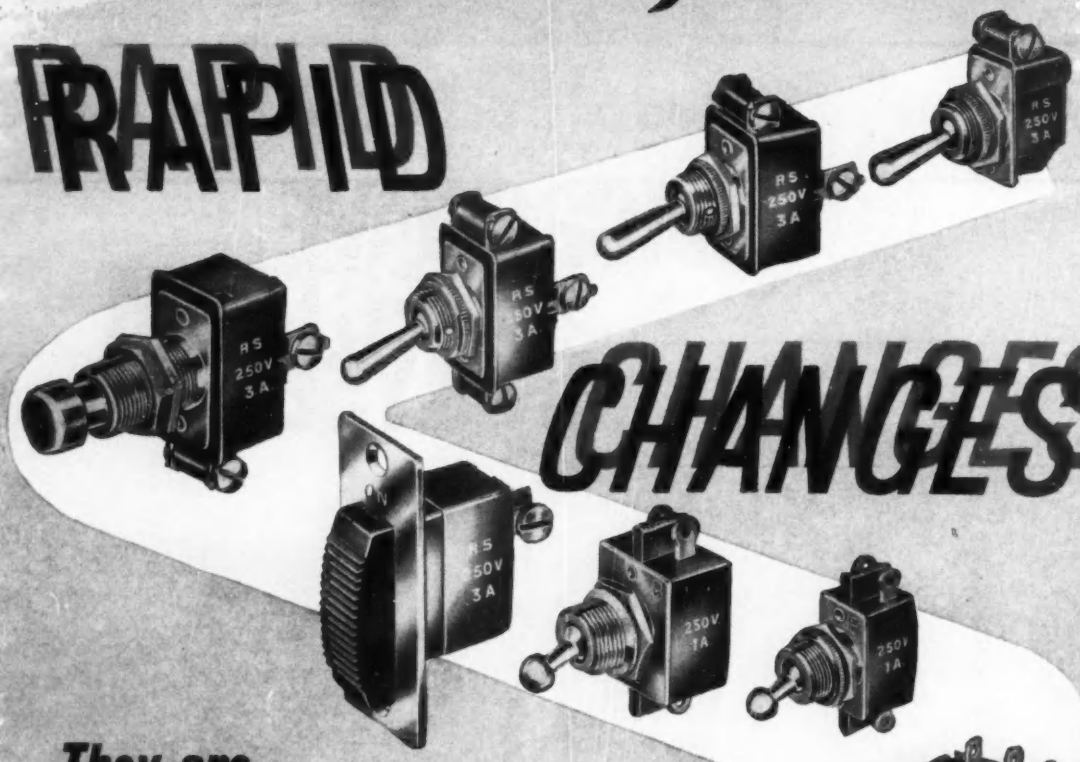

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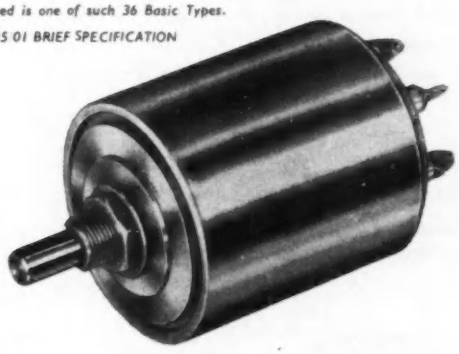

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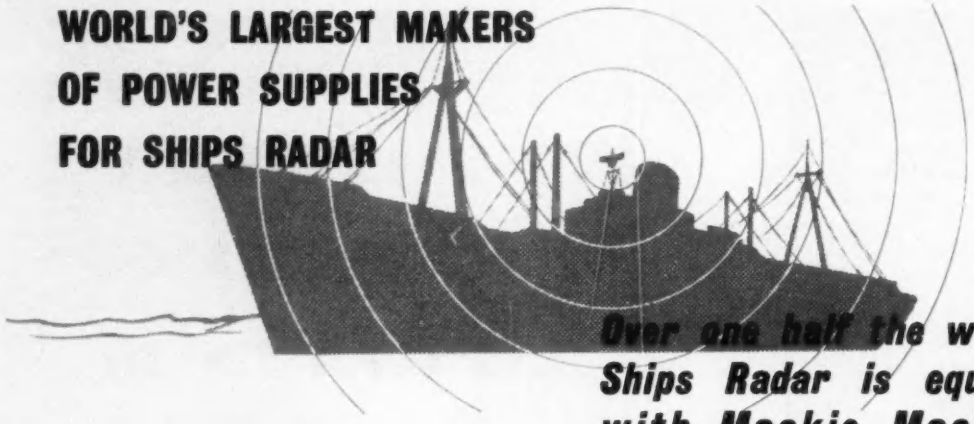

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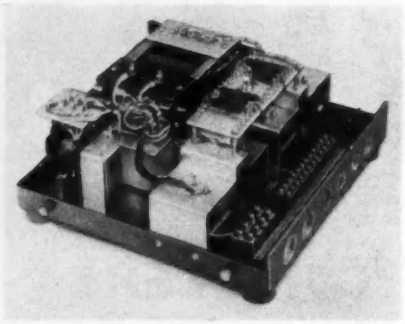

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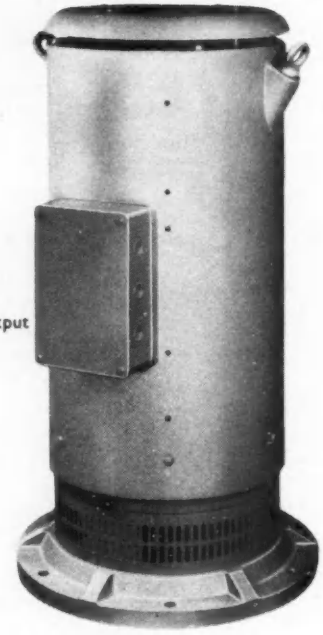

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3rd	0.1	0.06	0.07
4th	—	0.06	0.07
5th	0.32	0.47	0.97
7th	0.1	0.11	0.5
11th	Negligible	0.1	0.56
13th		0.1	0.46
17th		Negligible	0.45
19th			0.58
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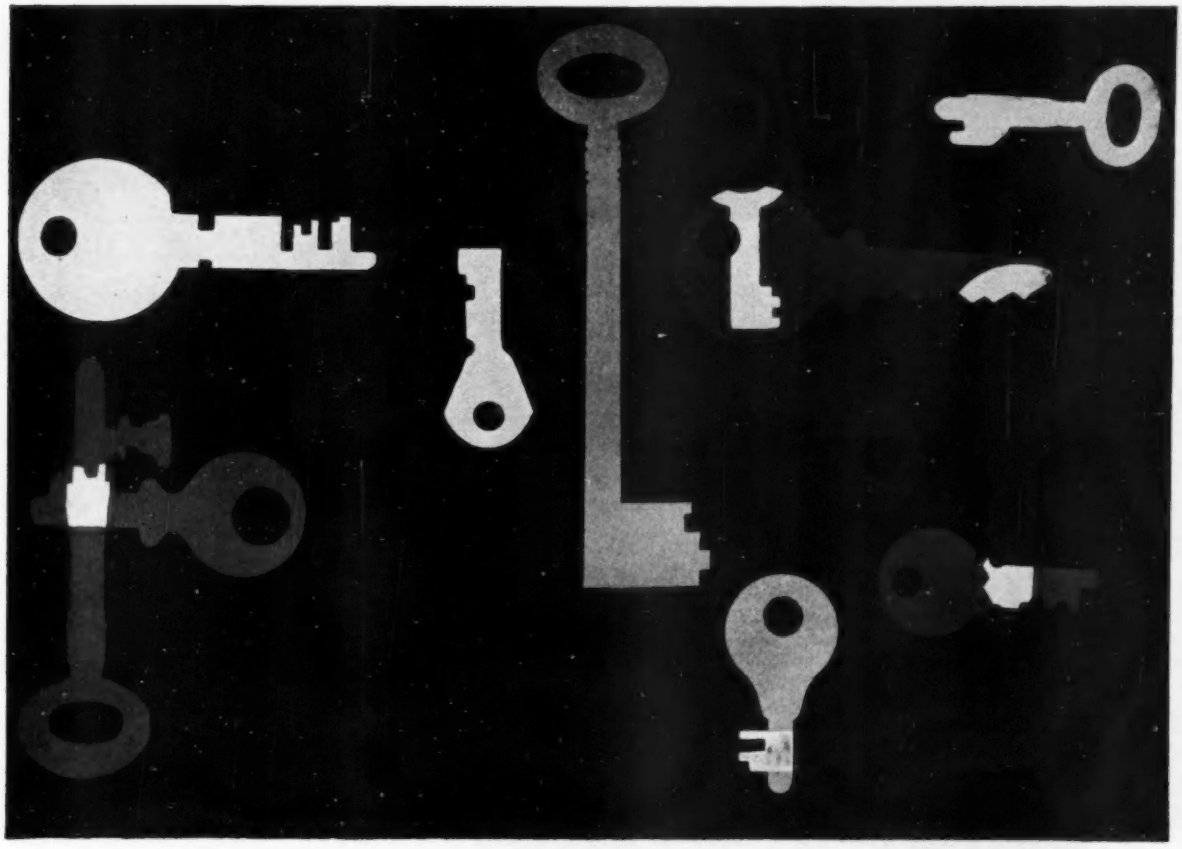

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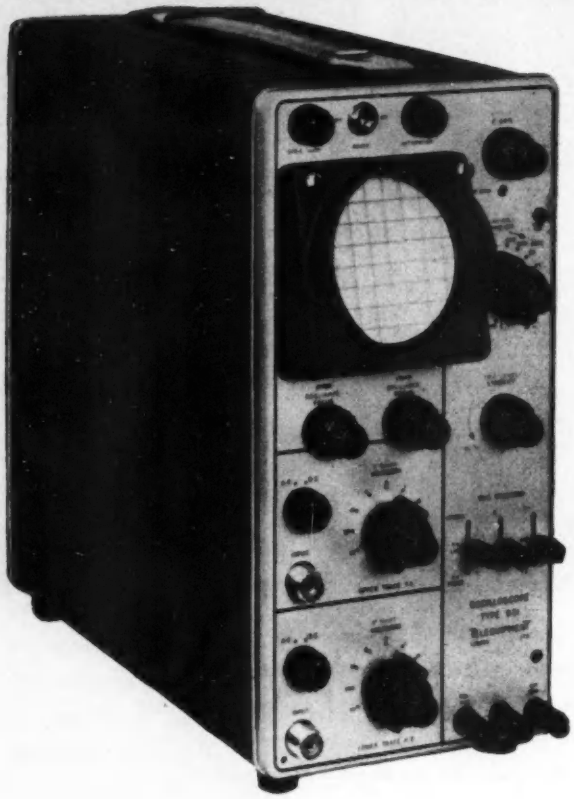
D31



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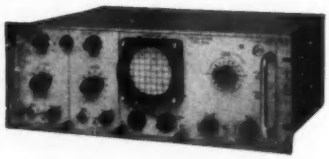

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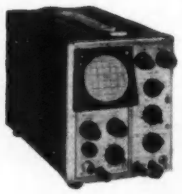

S31

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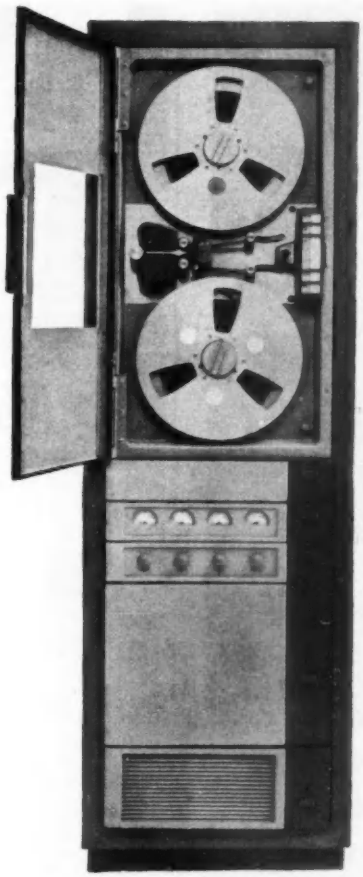

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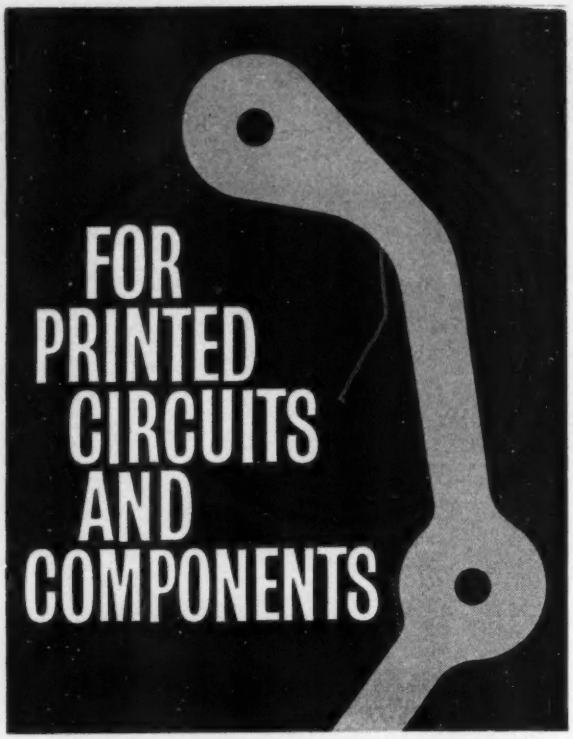

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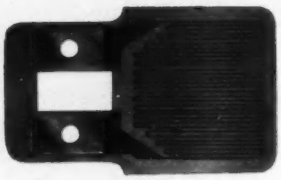

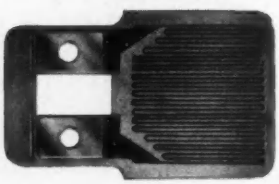

These 50 OHM printed resistors (approx. ⅛ in. sq.) were developed for Joseph Lucas Ltd and are in volume production. A Mills & Rockleys patent

TGA P52

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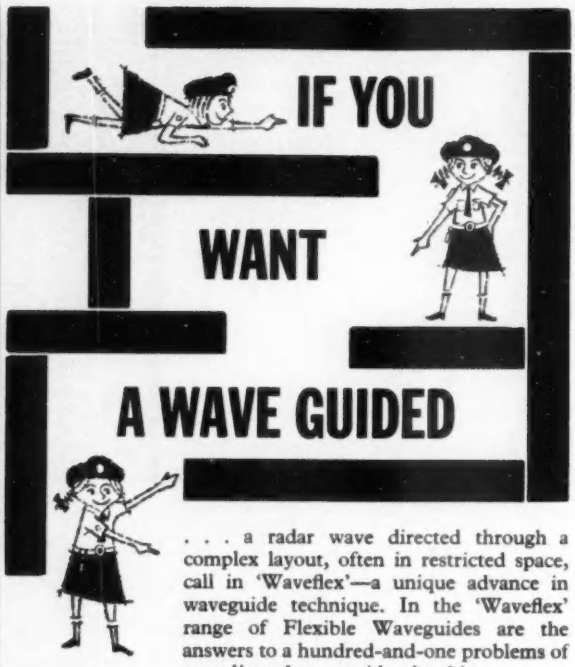

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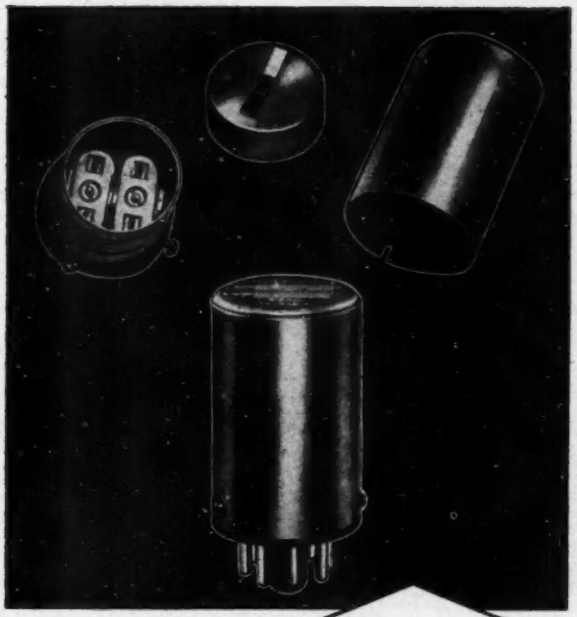

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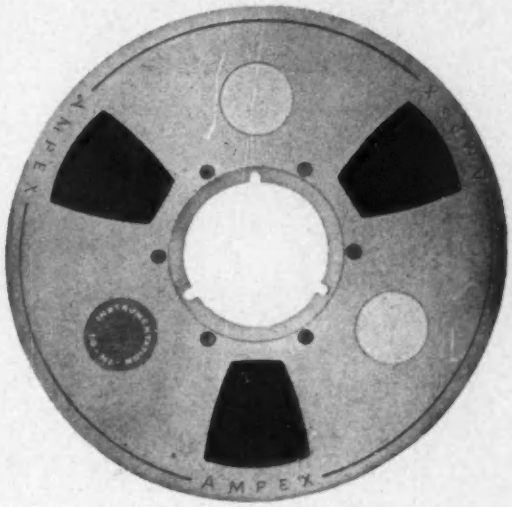

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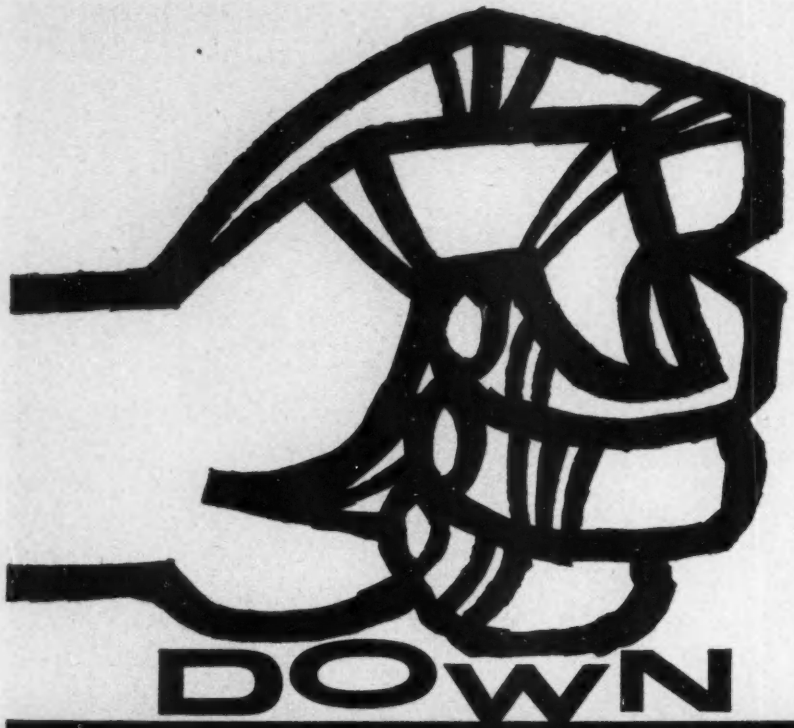

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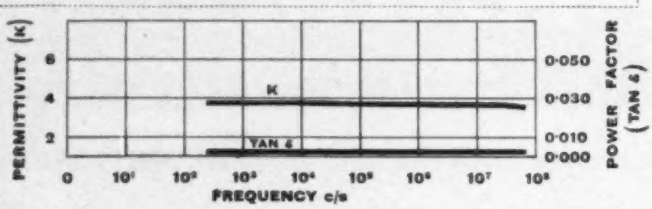
Flexural strength, lb/sq in	30,000–50,000
Water absorption after 24 hrs immersion, %	0·07–0·02
Power factor at 10^6c/s	0·001–0·003
Permittivity, at 10^6c/s	3·6–4·2
Electric strength ¼" thick, V/mil	200–500



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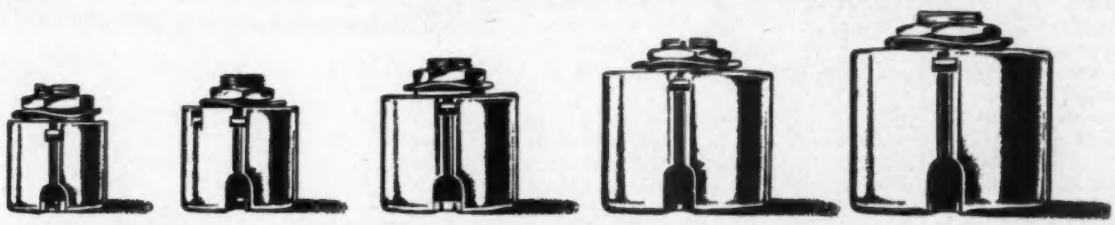

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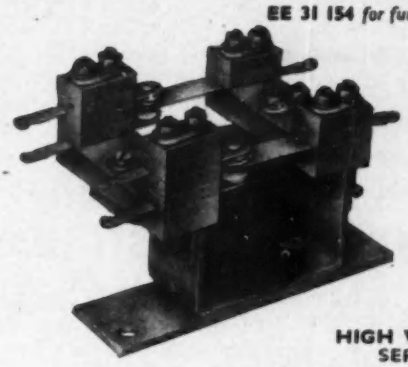

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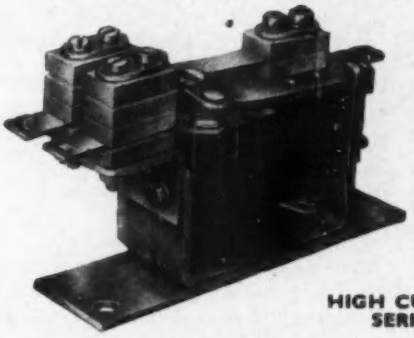

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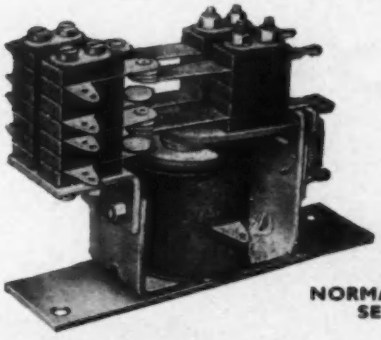

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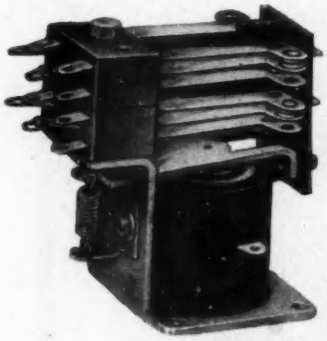

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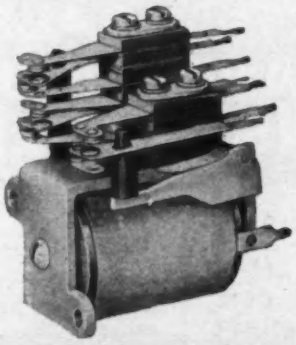

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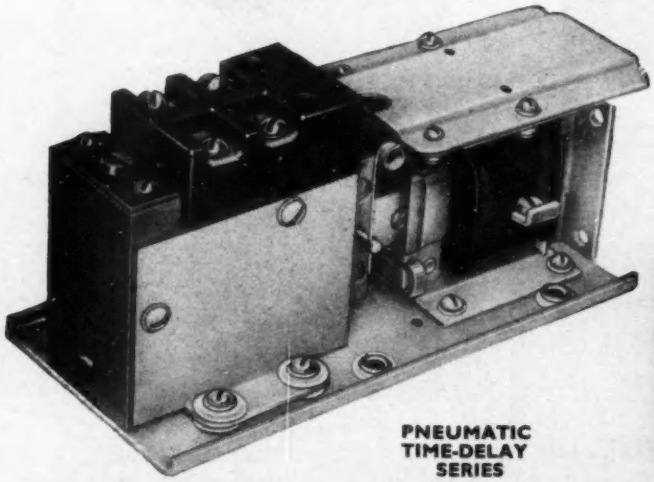

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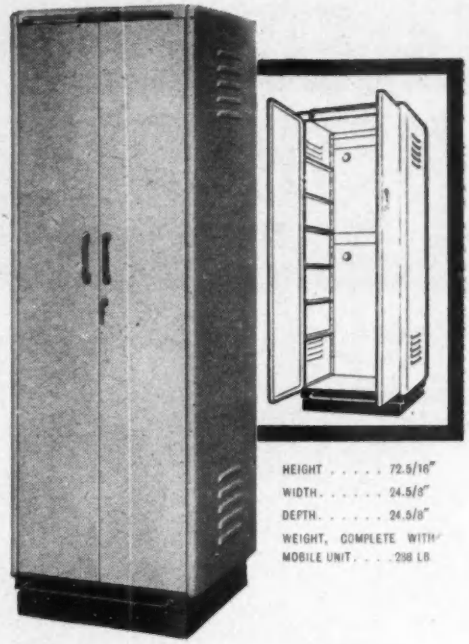

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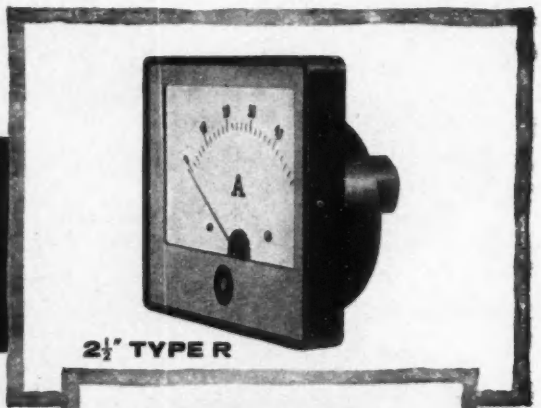

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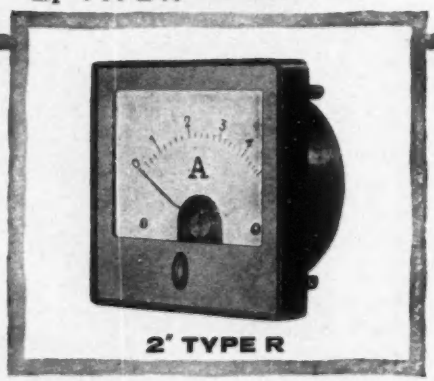

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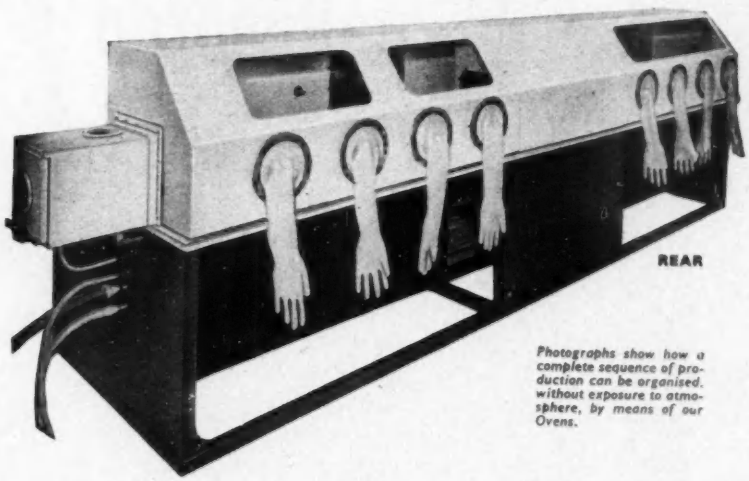

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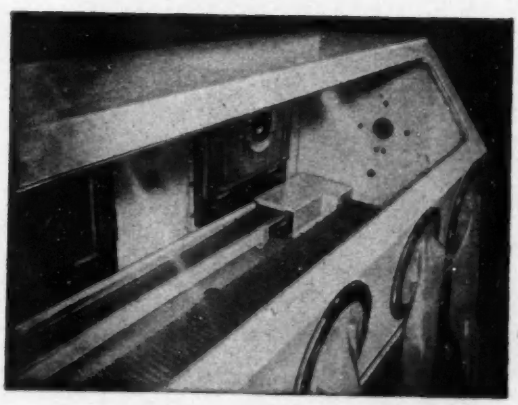

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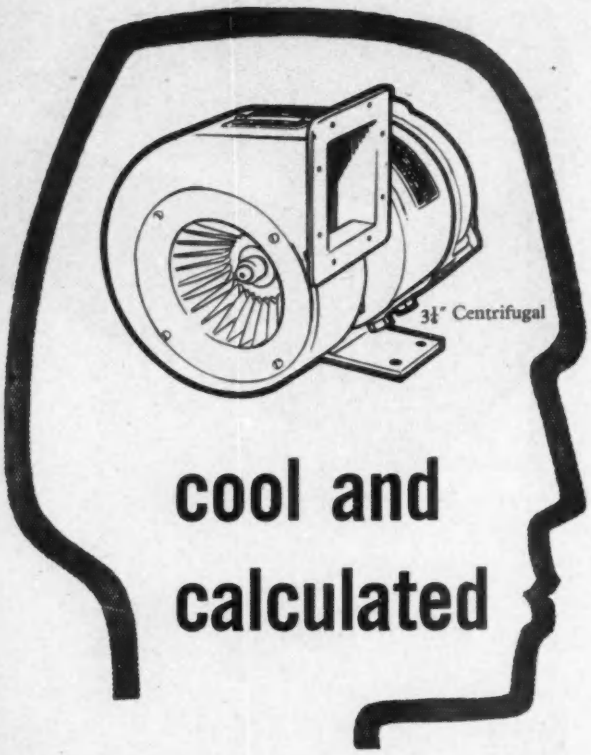

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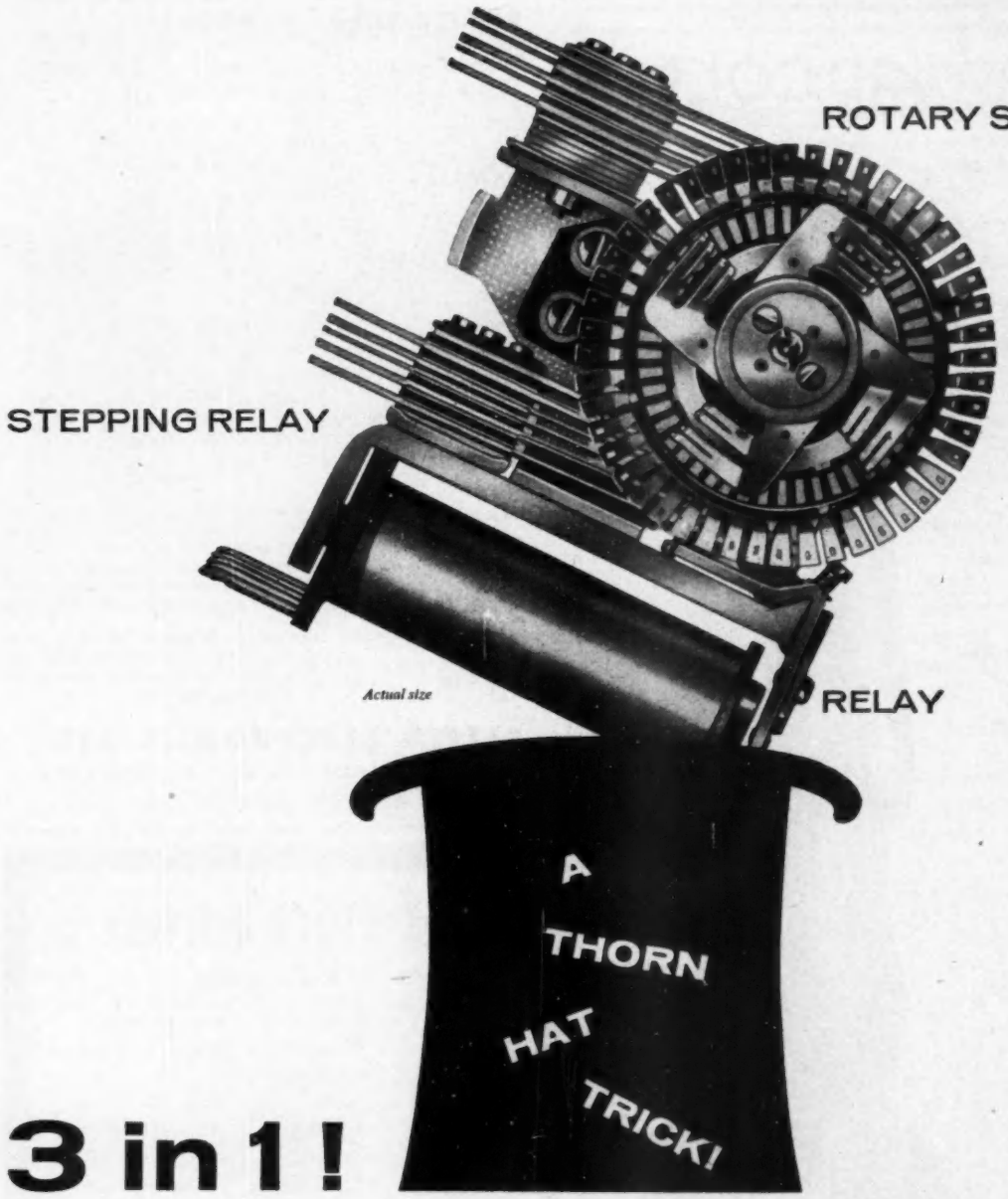

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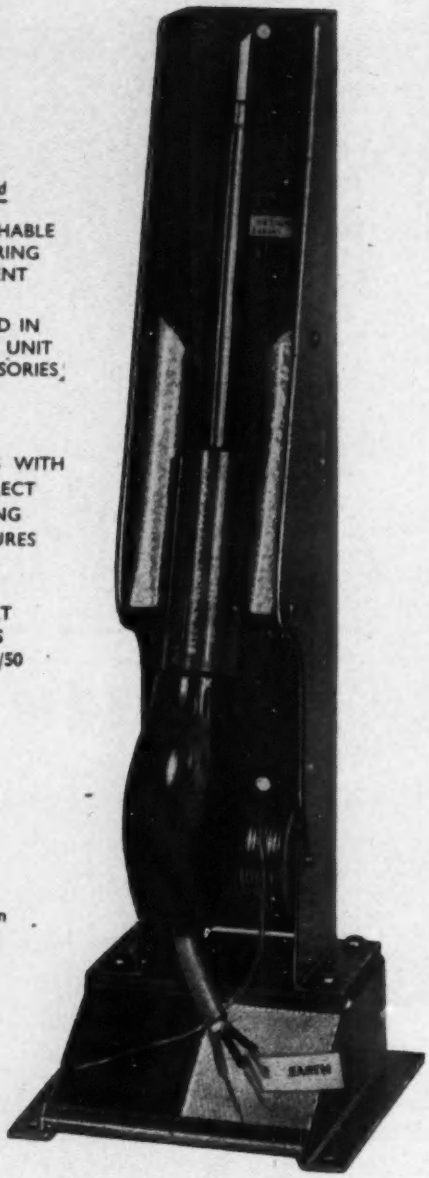

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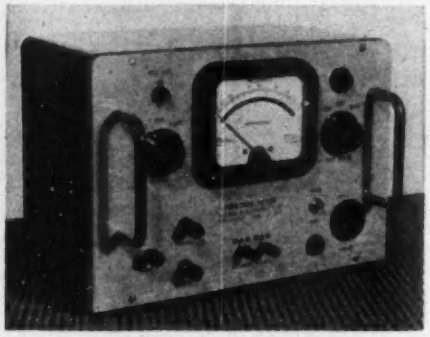

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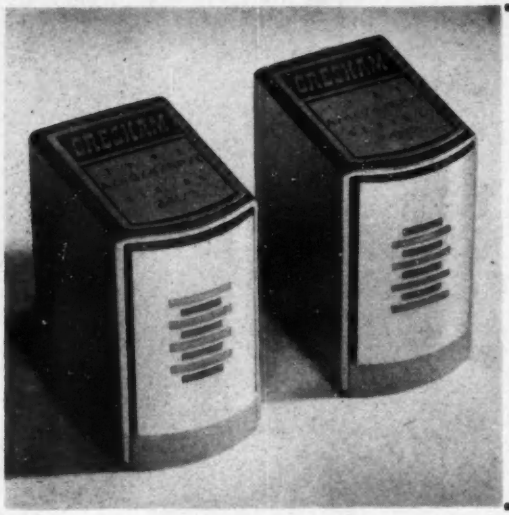

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Type A40/4/RP
INTERLACED HEADS FOR LOW CROSS-TALK .040" TRACK WIDTH

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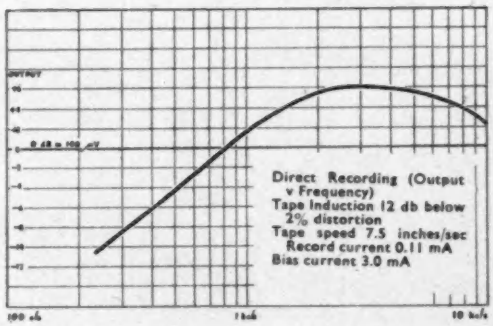
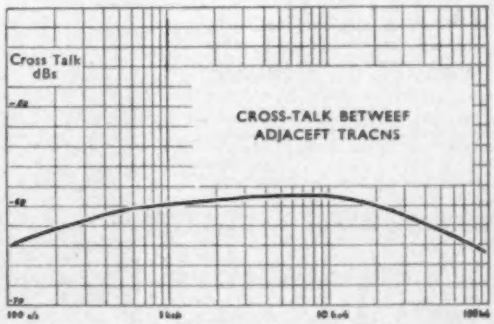
Depth: 1.3 inches inc. terminals.
Width: 0.7 inches
Track width: 0.040 inches ±.001
Track Spacing: 0.120 inches ±.001
Gap length: 0.00025 inches ±20%
Pole length: 0.192 inches ±.005
Heigth of lower edge of bottom track from base: Upper—0.538 inches ±.001
Height of lower edge of bottom track from base: Lower—0.478 inches ±.001
Azimuth, vertical to base, within ±.0005 radians
Elevation, vertical to base, within ±.001 radians
Inductance (2 coils in series) 10 milli-Henries ±25%
Resistance (2 coils in series) 10 ohms ±25%


Direct Recording (Output v Frequency)
Tape Induction 12 db below 2% distortion
Tape speed 7.5 inches/sec
Record current 0.11 mA
Bias current 3.0 mA



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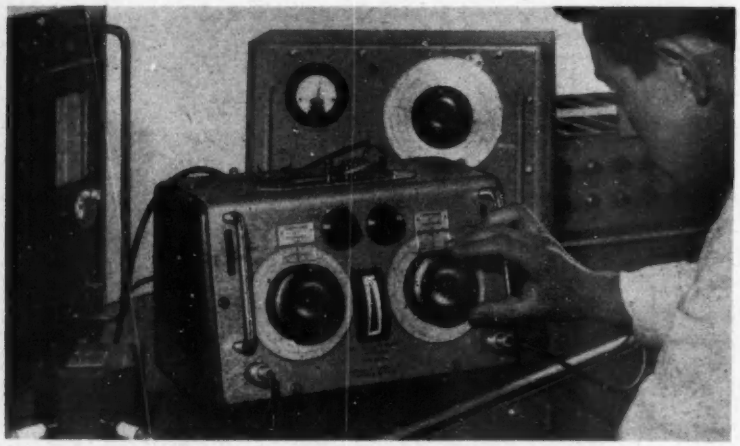

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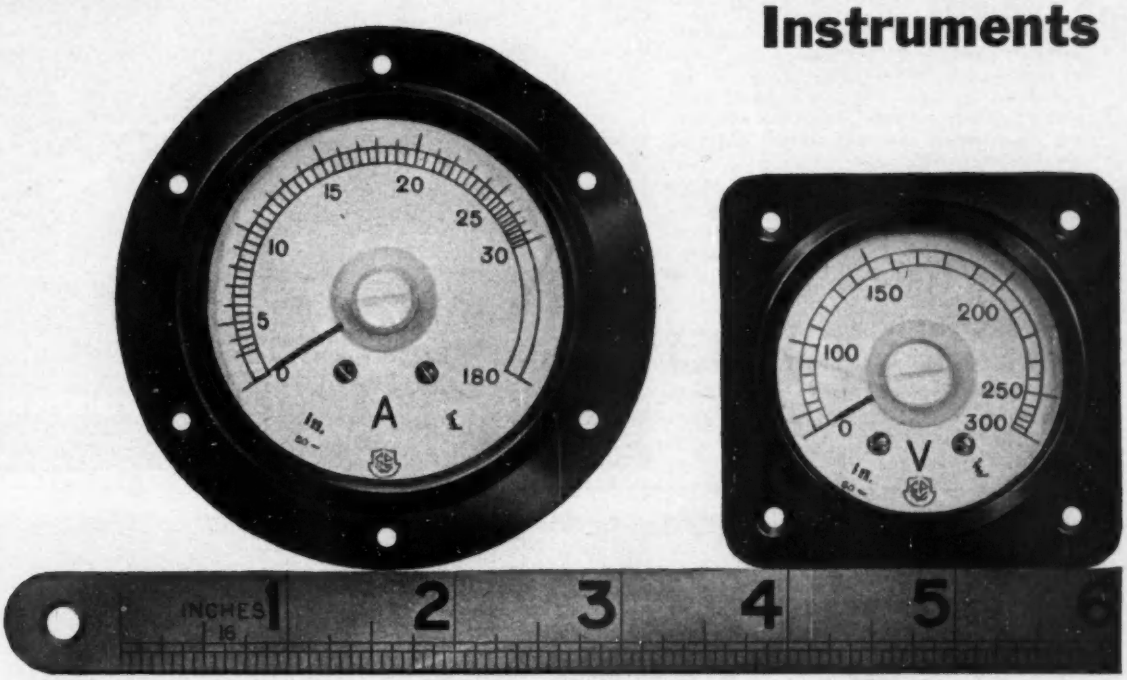

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THE SLEE WELDER

Illustrated here is type "RK2" which is unique in that it combines High Speed accurate welding with the minimum of effort and skill on the part of the operator. The frictionless electrode system precisely controls, apart from positioning, the structure throughout every phase of the complex welding cycle.

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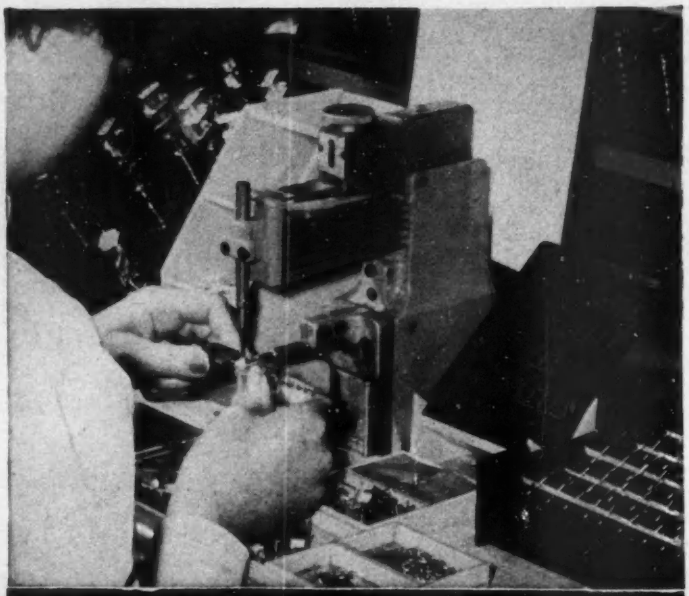

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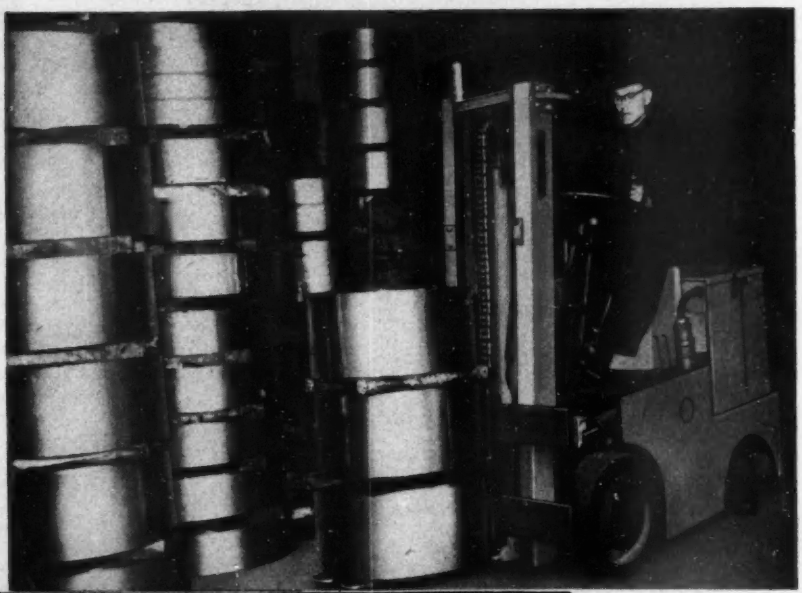

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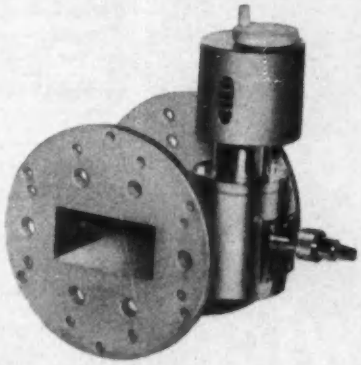
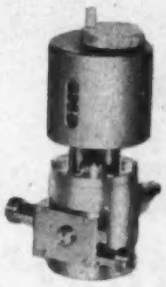
DIRECT READING FREQUENCY METERS

Type No.	Frequency Range kMc/s
SL 7510	1.1— 1.7
SL 5815	1.55— 2.5
SL 5212	2.5 — 4.0
SL 5590	3.3 — 4.9
SL 5174	3.8 — 5.9
SL 7599	4.5 — 7.29
SL 5585	5.4 — 8.6
SL 7100	7.05—11.2
SL 5205	8.2 —12.4
SL 7095	12.4 —18.0



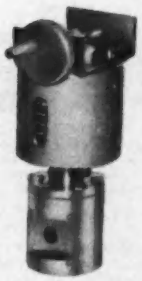
The SIVERS LAB Direct Reading Frequency Meters enable a quick and accurate determination of frequencies in the Microwave region to be made. The frequency range from 1kMc/s to 18kMc/s is covered by 10 models. Each model operates over the full waveguide bandwidth, with direct reading accuracy better than $\pm 0.1\%$. The frequency meters have two coupling windows, to which the basic elements below can be connected.

Attachments and remote controls are available to enable the Frequency Meter to be included in the interior of a system with the control and frequency indication on the front panel.



WAVEGUIDE SWITCHES

Available types	Frequency Range kMc/s	Waveguide Type No.
SL 5980/41/51/42/52	2.6 — 3.95	WR284—WG10
SL 7490/41/61/42/62	3.3 — 4.9	WR229—WG11A
SL 5990/41/61/42/62	3.95— 5.85	WR187—WG12
SL 7010/41/61/42/62	5.85— 8.2	WR137—WG14
SL 7020/41/61/42/62	7.05—11.0	WR112—WG15
SL 5600/41/61/42/62	8.2 —12.4	WR 90—WG16
SL 7030/41/61/42/62	12.4—18.0	WR 62—WG18



First suffix means circuit as above. Second 1 or 2 mean manual or automatic type.

SIVERS LAB has a long experience of waveguide switches, both manual and automatic types. The newest designs are further improved both mechanically and electrically and provide an ideal solution for high and low power microwave systems.

The automatic types have been designed for use where very fast switching is required, e.g. for reversal, standby and measurement in radio links and in modern broadband radar systems fitted with two magnetrons.

For very fast switching automatic switches employ a spring which is rewound after each operation by means of a motor, driven from a low voltage d.c. supply or a small rectifier. Remote indication is provided.

The low VSWR of less than 1.05, in some types below 1.02, makes both types suitable in laboratory use to speed-up tests on microwave tubes and components.

The isolation between different channels is at least 80 up to 100 dB over the whole frequency band. This makes testing of radar stations possible without disclosing frequency or geographical situation.

Both automatic and manual types are manufactured for frequencies from 1.1-18.0 kMc/s.

SIVERS LAB manufacture high precision microwave instruments and components for modern radar and radio links. For further information about our programme please ask for complete catalogue.

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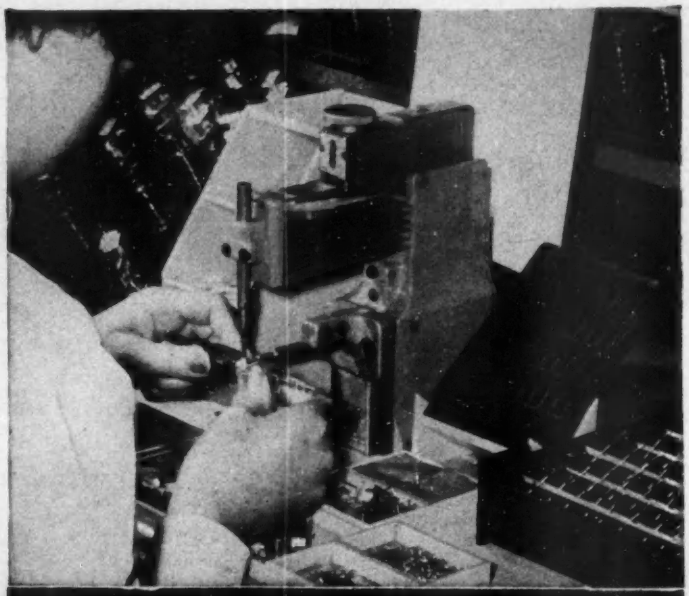

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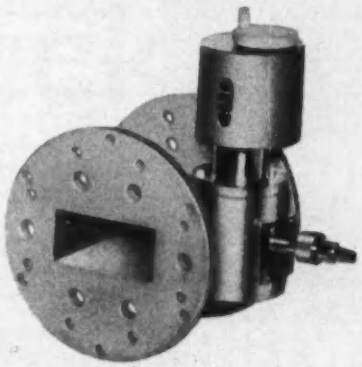

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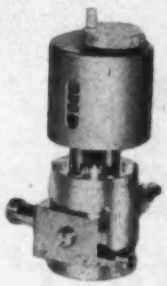

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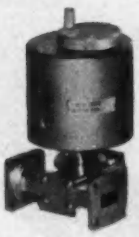

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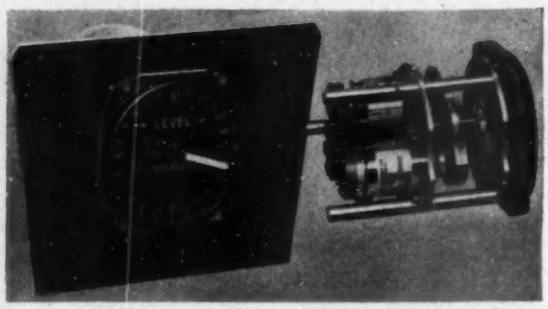

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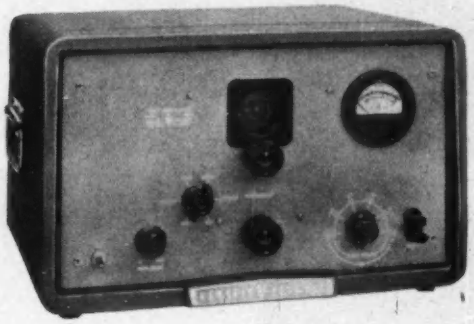

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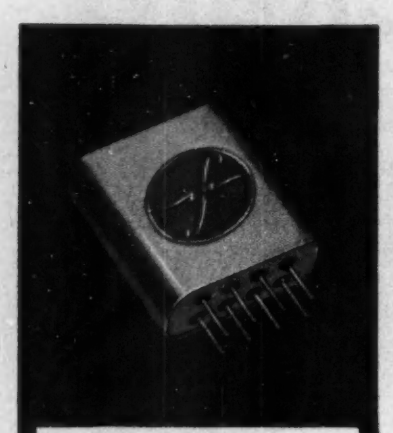

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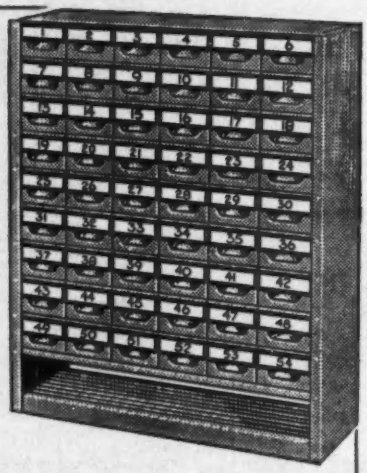

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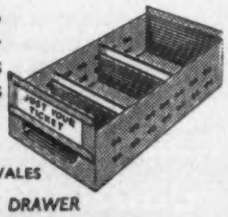

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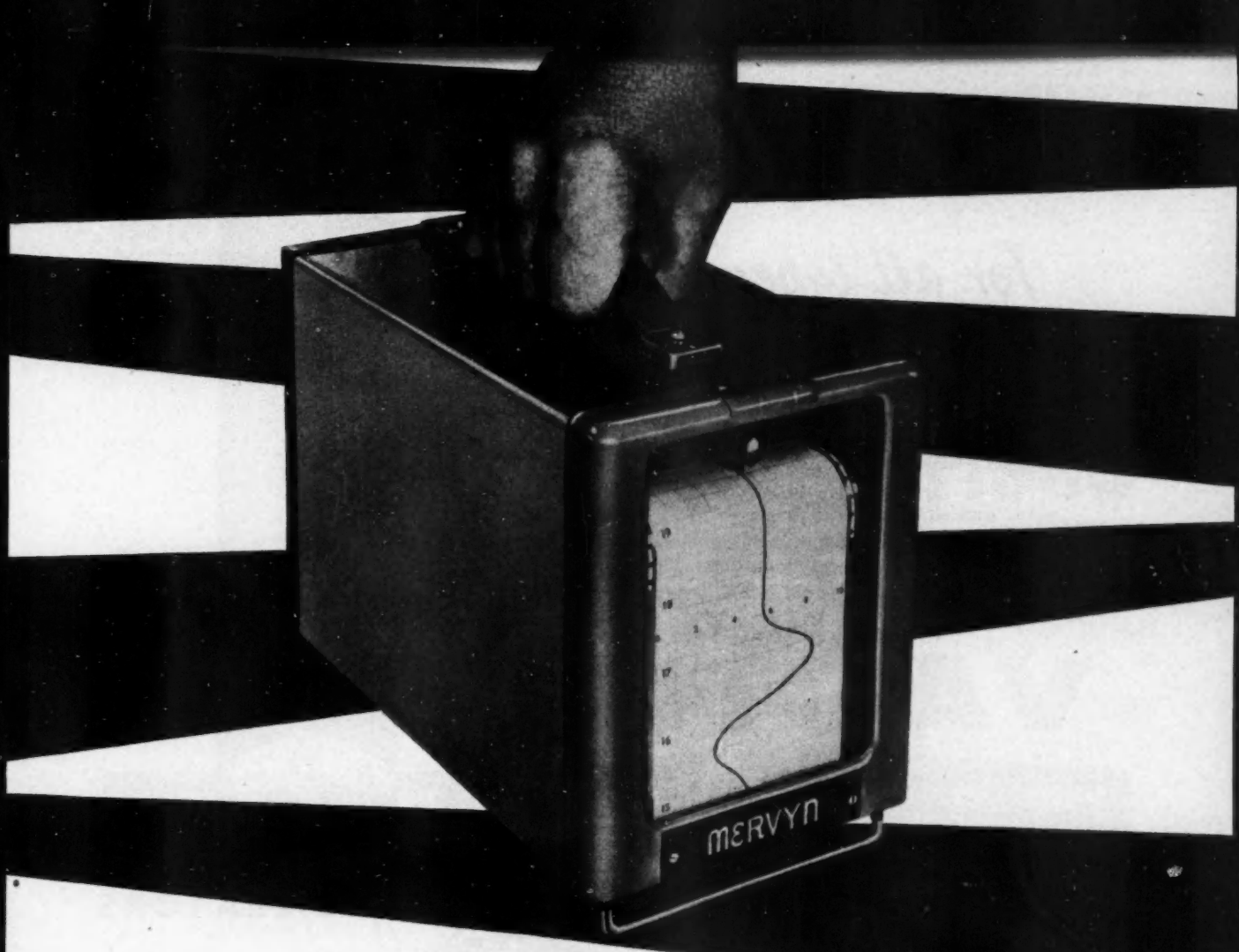

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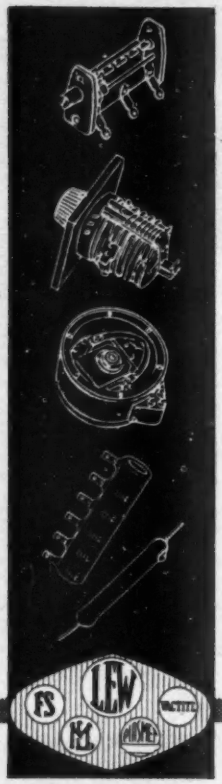

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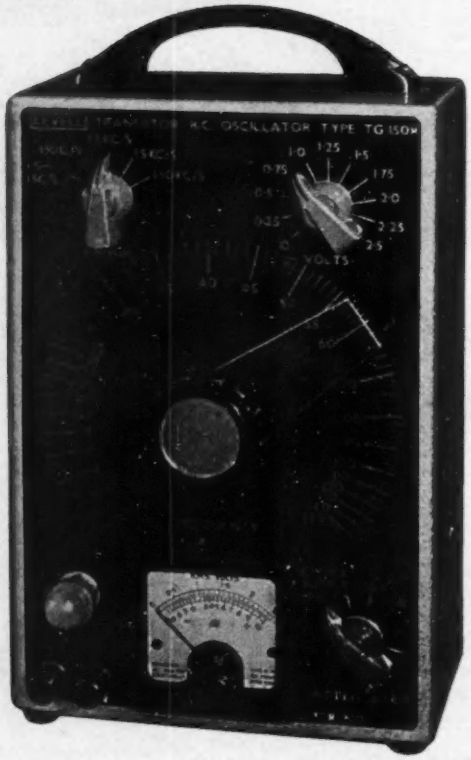

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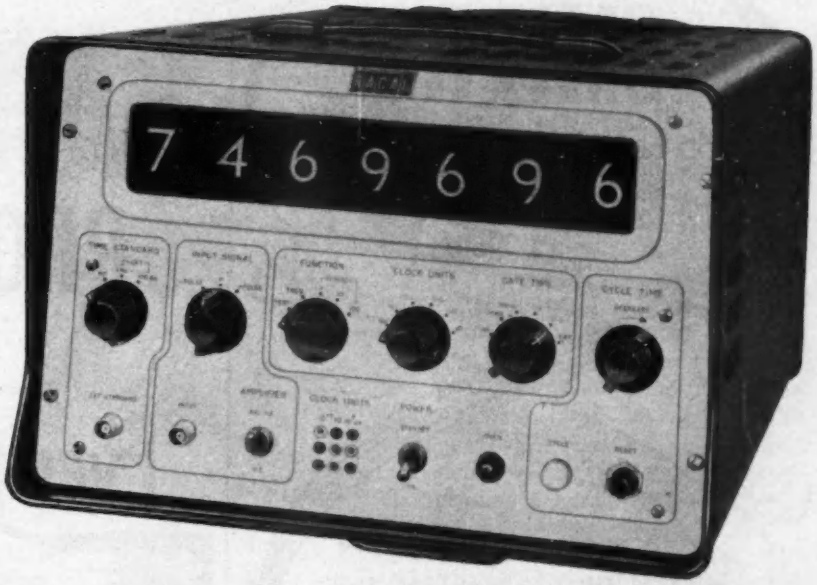

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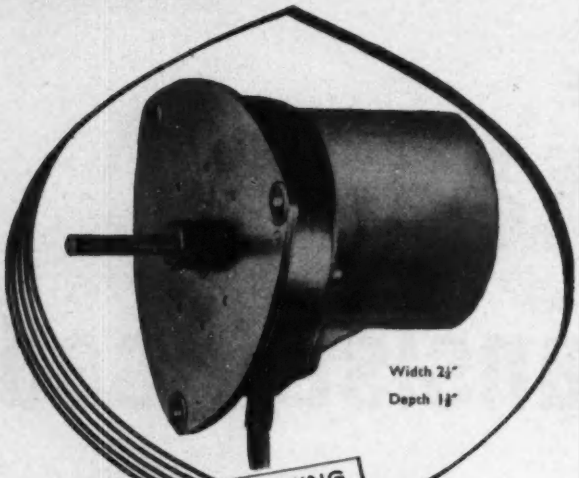

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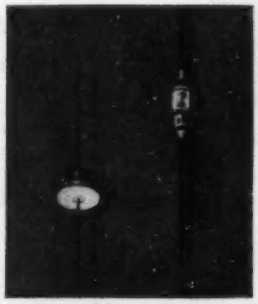

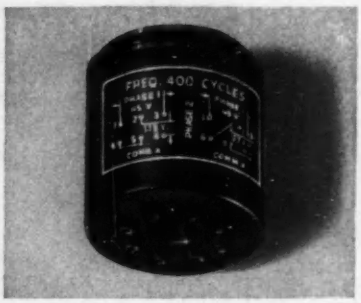

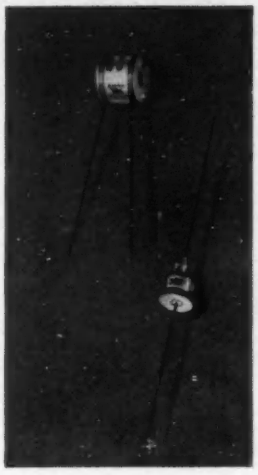

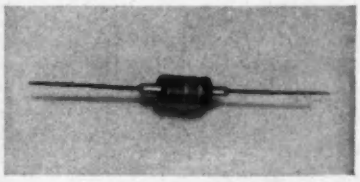

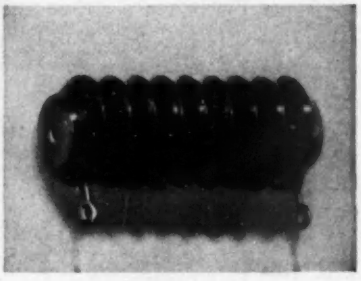

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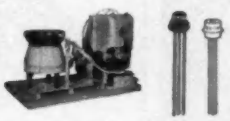

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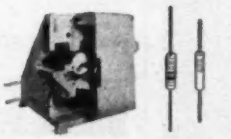

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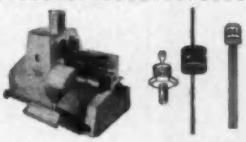

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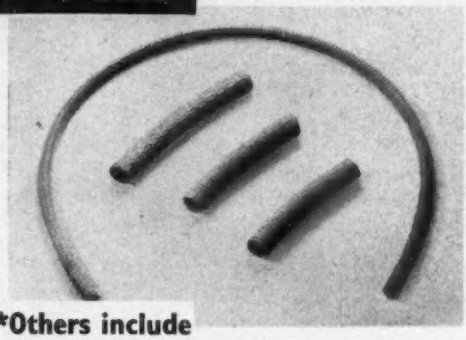

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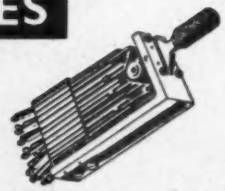

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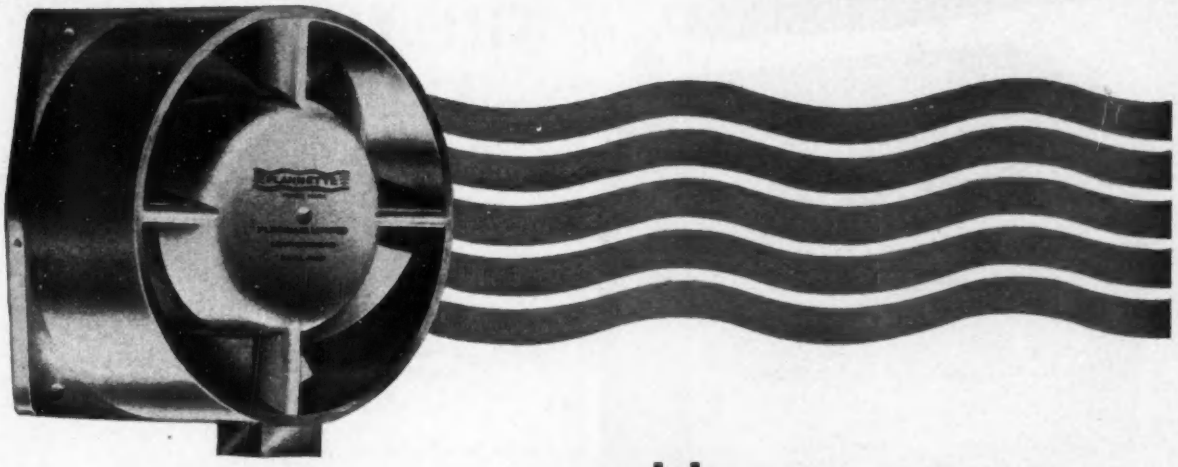
meet the [redacted] PLANNETTE



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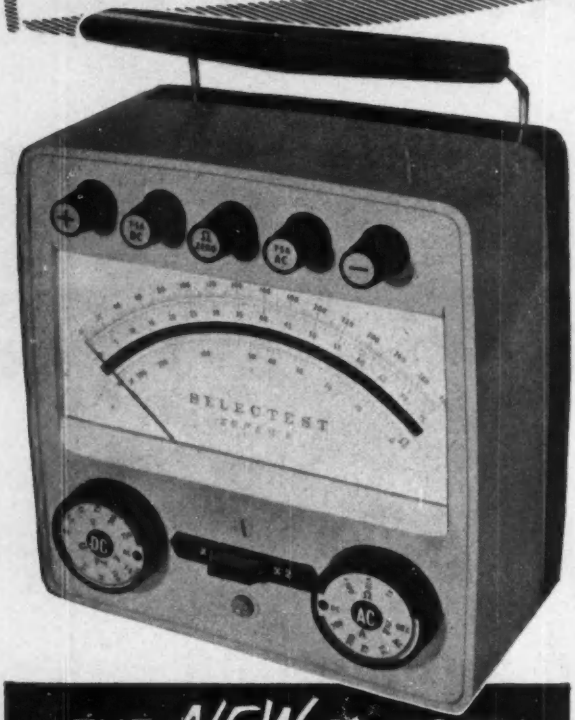

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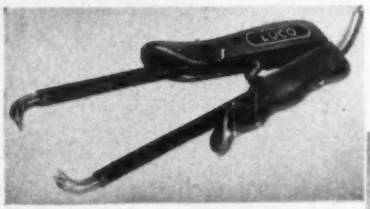

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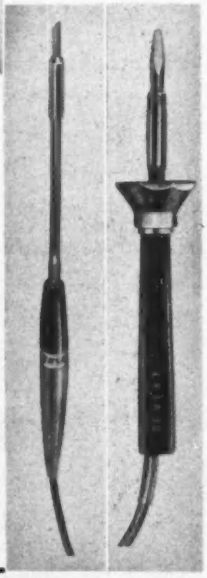

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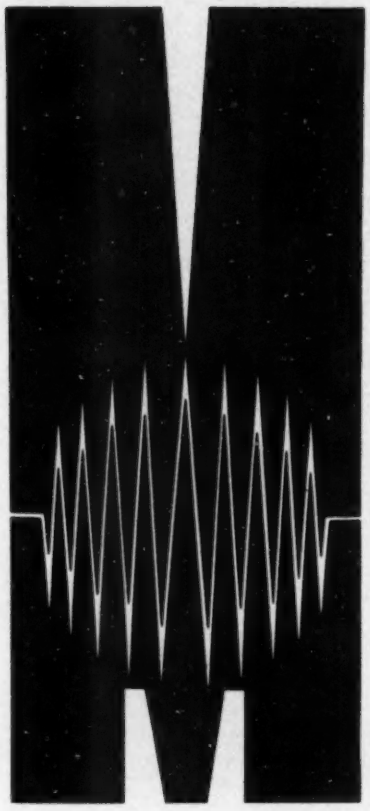

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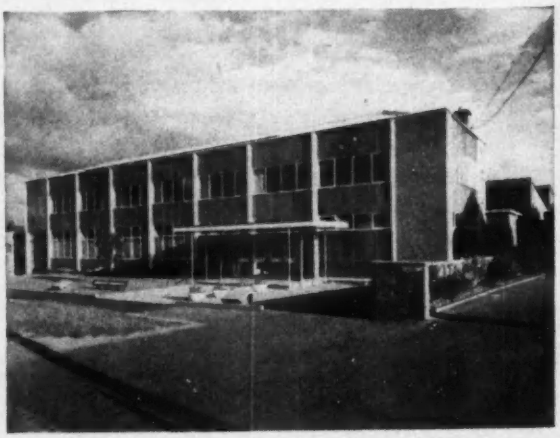

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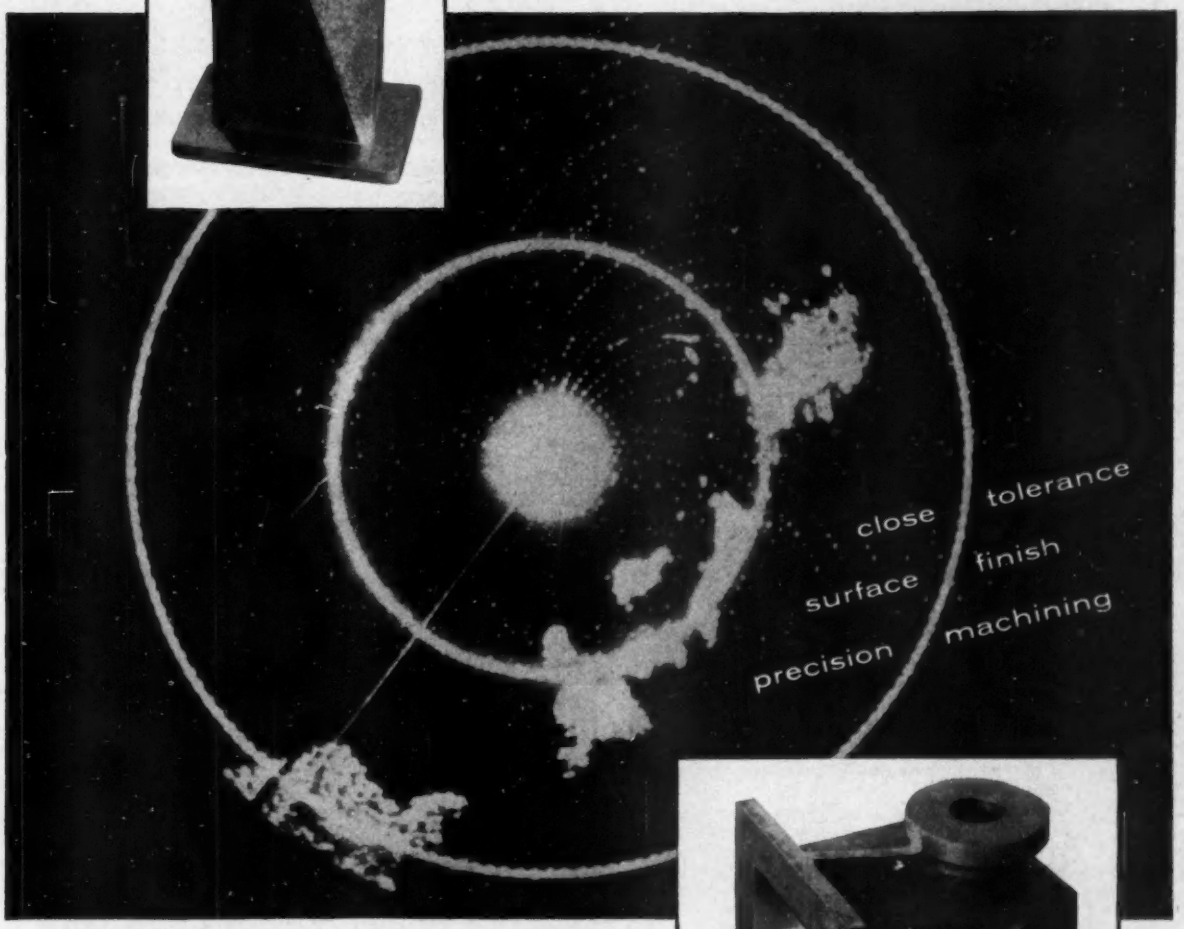

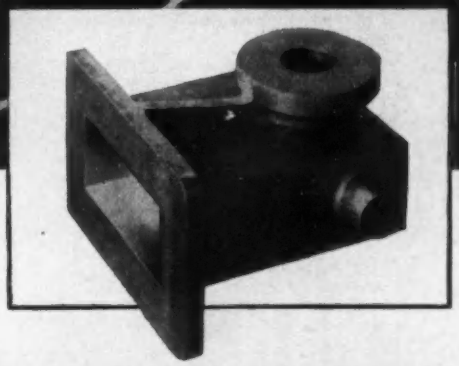

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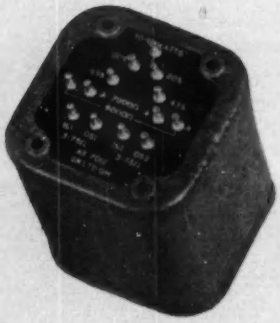

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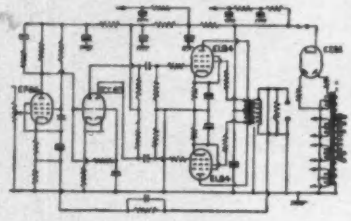

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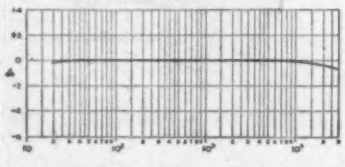
Below is reproduced the Response Curve of the AS.7012 which is typical of the whole of the Solent Series.



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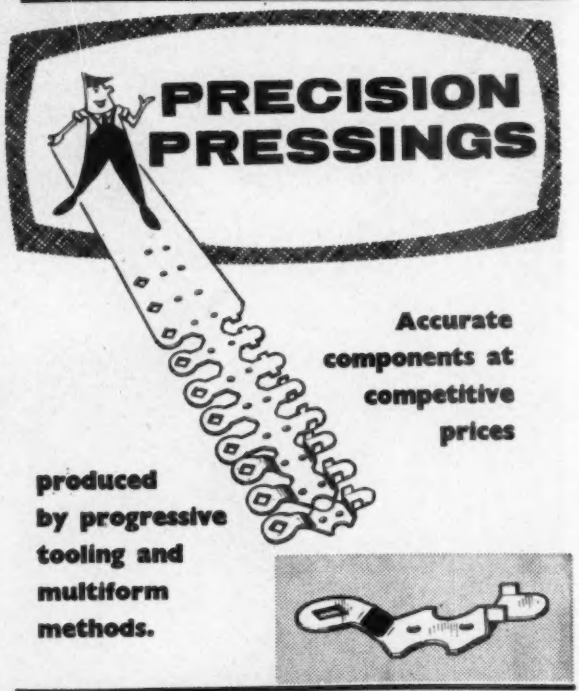

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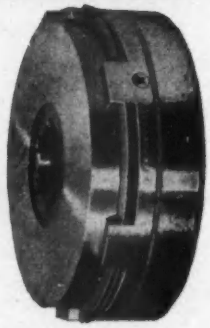

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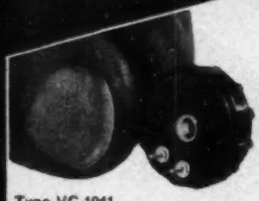

Type VC 1041

Type VC 1760

Type VC 1545

TYPICAL SPECIFICATION

Track maximum working voltage	200v DC
Switch maximum working voltage	50v AC or DC
Overall power handling of track	1W0 mW
Insulation resistance:	
Between switch and potentiometer (switch "on")	100 MΩ at 100v DC
Between switch contacts (switch "off")	10 MΩ at 100v DC
Initial resistance	0.1% ⎫ typical figure given for a
Final resistance	5% ⎭ 200 KΩ control
Switch DC contact resistance	Not greater than 8 mΩ
Switch contact rating	150 mA at 50v
Noise level	Not greater than 270 microvolts at 1 microamp DC. Typical figures for 200 KΩ track
Turning torque over track	0.25 to 1.5 oz.ins., 18 to 108 g.cms.
Turning torque for switch operation ("on" or "off")	At least 0.5 oz.ins., 36 g.cms. greater than track torque, 0.75 to 5 oz.ins. 54 to 360 g.cms.
Total angle of rotation	283°
End stop torque	1.25 lb.ins., 1440 g.cms.
Weight	0.073 oz., 2.06 g.

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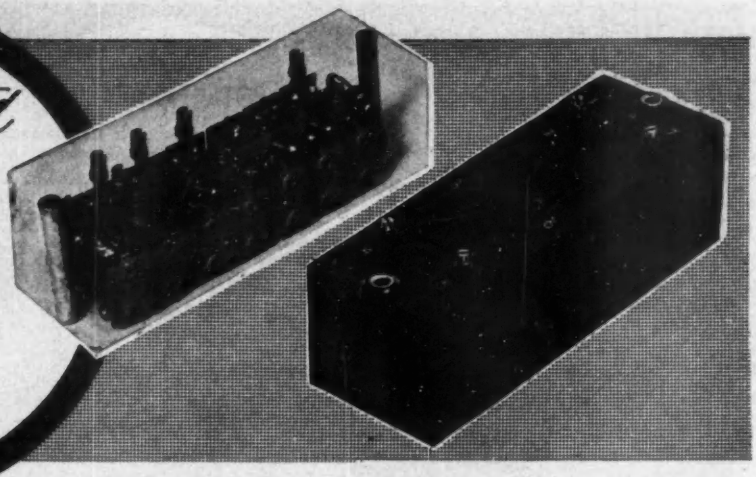

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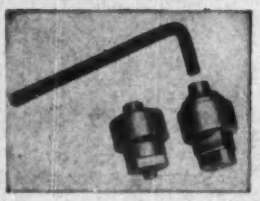

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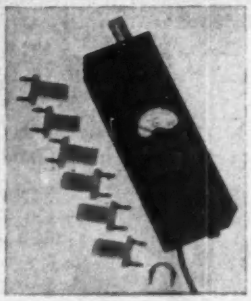

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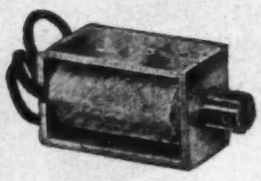

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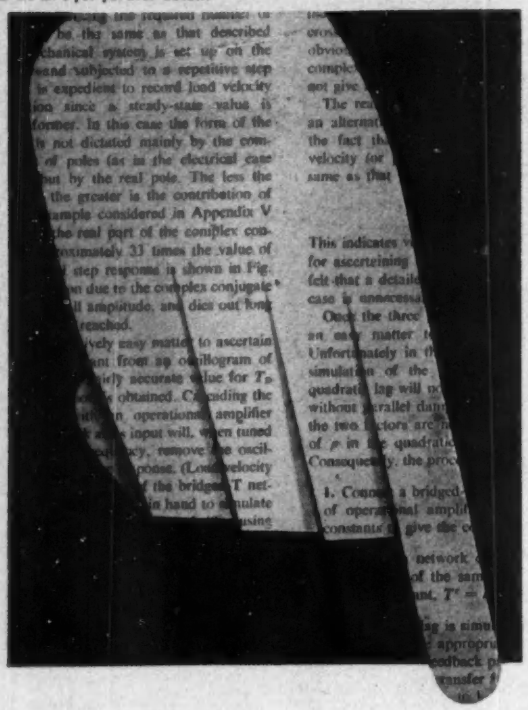

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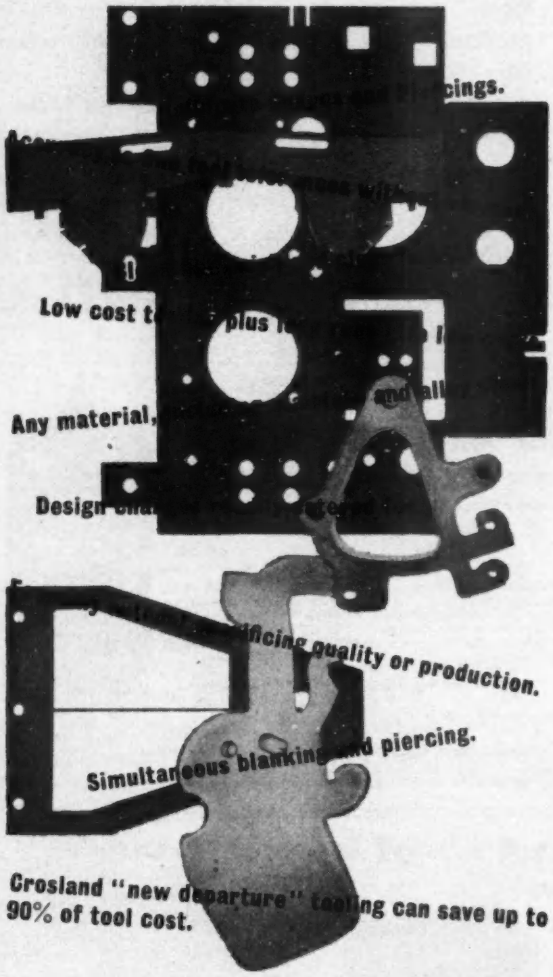

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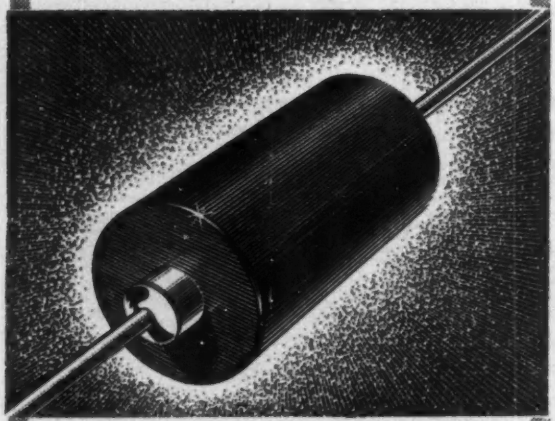

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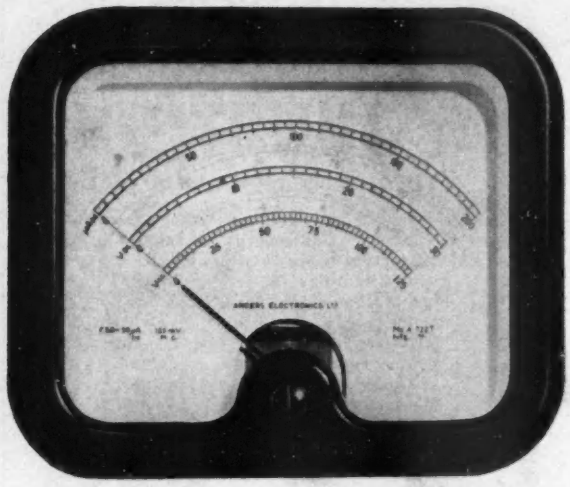

This seven-range meter, using Ernest Turner Model 605 was calibrated with special ranges by Anders at short notice for Elliott Brothers Ltd. for the special-purpose test gear shown right. All the meters in this complex installation were supplied by Anders, who have the pleasure of carrying out similar work for a number of famous manufacturers. Anders are indebted to Elliott Brothers for kind permission to illustrate this equipment.

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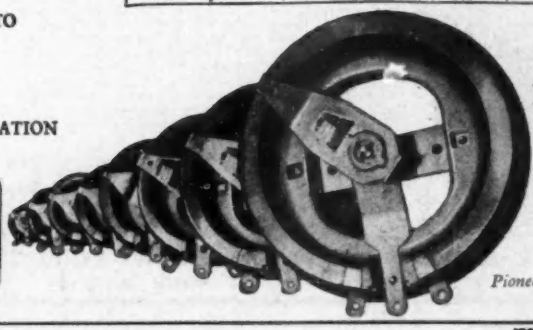
3	2.89	4.08	5.00	5.75	7.07	8.66	10.0	12.9
5	2.24	3.16	3.88	4.77	5.48	6.71	7.75	10.0
7.5	1.82	2.58	3.16	3.65	4.47	5.48	6.32	8.17
10	1.58	2.24	2.74	3.16	3.88	4.74	5.48	7.07
15	1.29	1.83	2.24	2.58	3.16	3.87	4.47	5.78
25	1.00	1.41	1.73	2.00	2.45	3.00	3.46	4.47
50	.707	1.00	1.23	1.41	1.73	2.12	2.45	3.16
75	.578	.818	1.00	1.15	1.41	1.73	2.00	2.58
100	.500	.707	.866	1.00	1.23	1.50	1.73	2.23
150	.408	.575	.707	.818	1.00	1.22	1.41	1.82
200	.354	.500	.612	.707	.866	1.06	1.22	1.58
350	.268	.378	.463	.535	.655	.803	.926	1.19
500	.224	.316	.388	.447	.548	.671	.775	1.00
1,000	.158	.224	.274	.316	.388	.474	.548	0.708
1,500	.129	.183	.224	.258	.316	.387	.447	.578
2,500	.100	.141	.173	.200	.245	.300	.346	.448
5,000	—	.100	.123	.141	.173	.213	.245	.315
7,500	—	.081	.100	.115	.141	.173	.200	.258
10,000	—	—	—	.110	.125	—	.173	.224
15,000	—	—	—	—	—	—	—	.183



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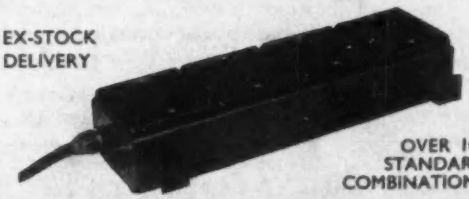

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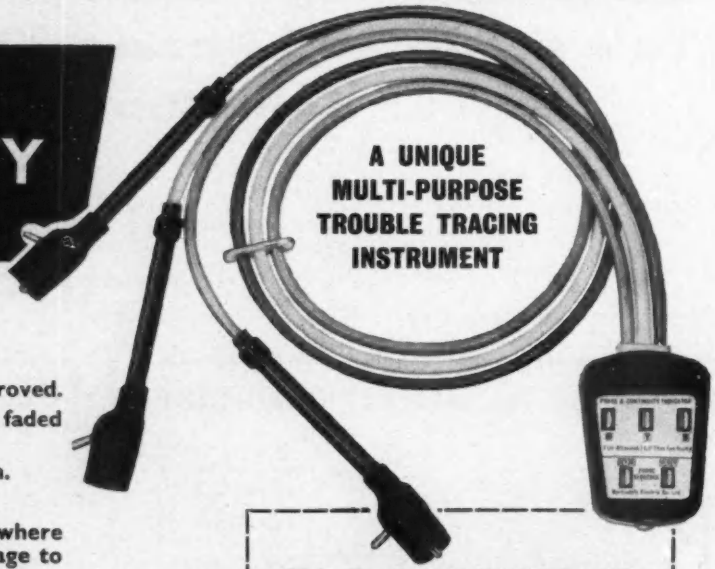

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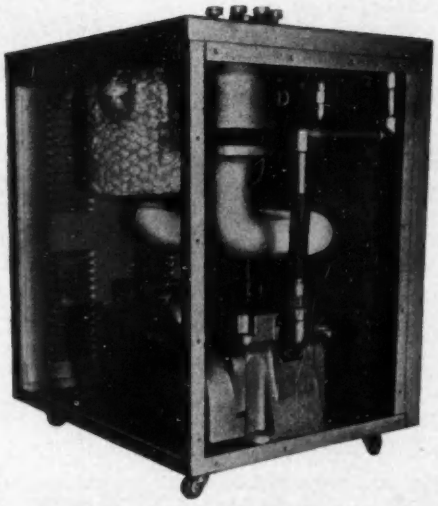

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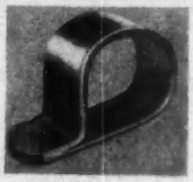

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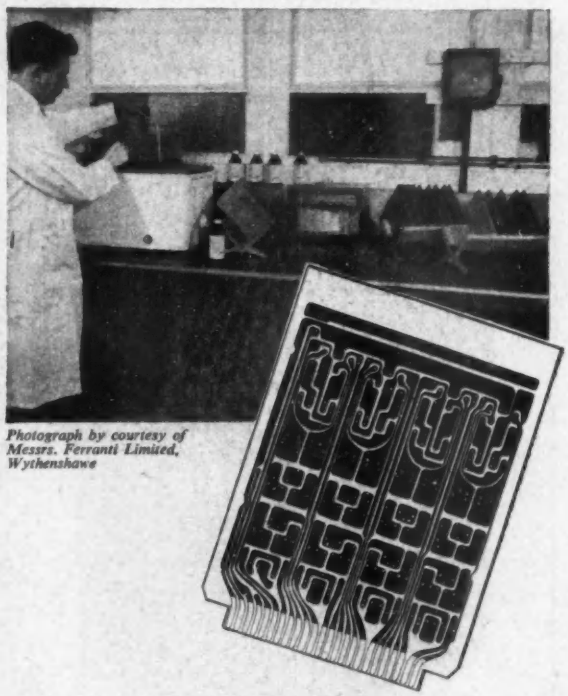

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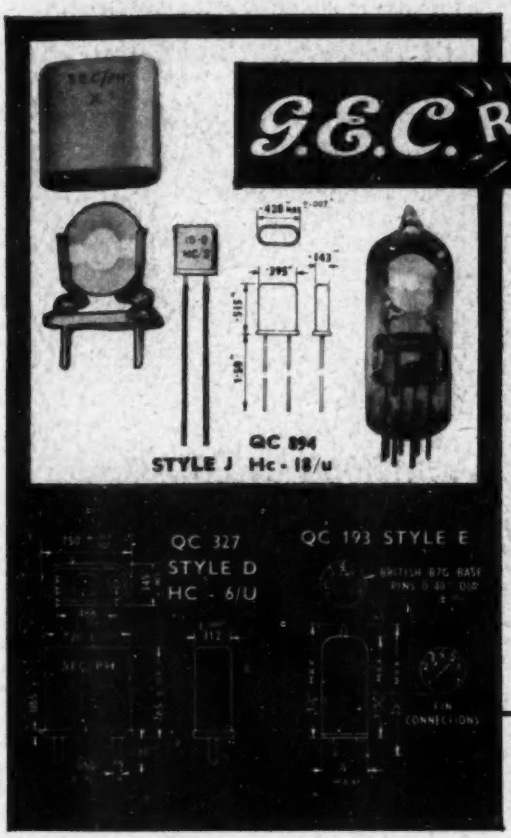

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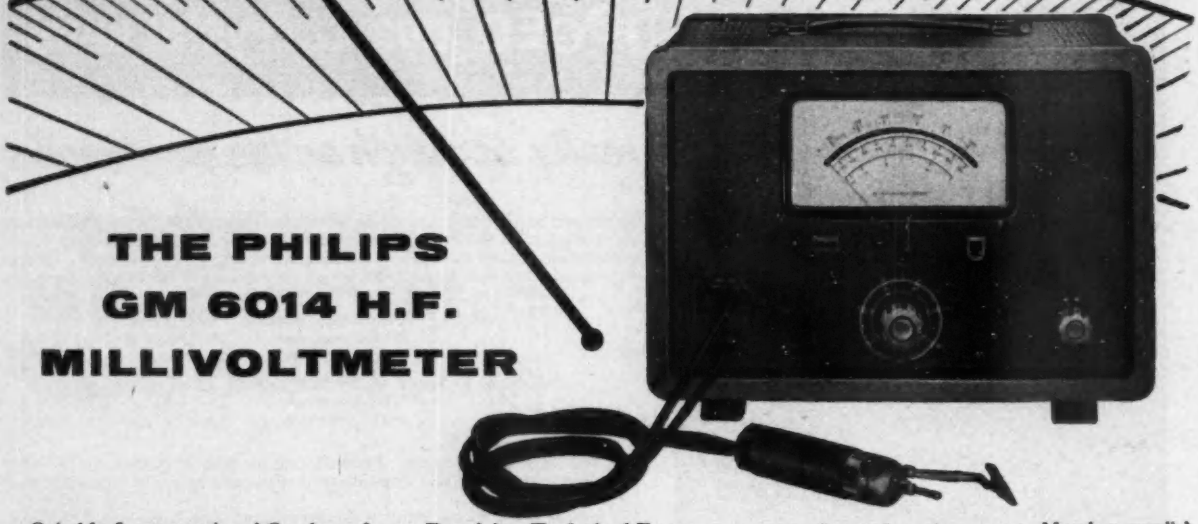

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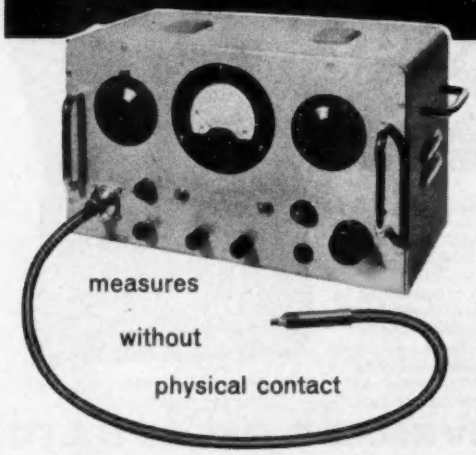

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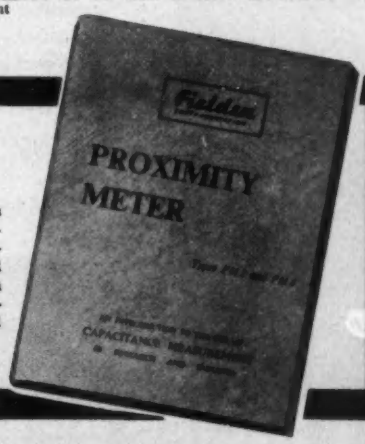

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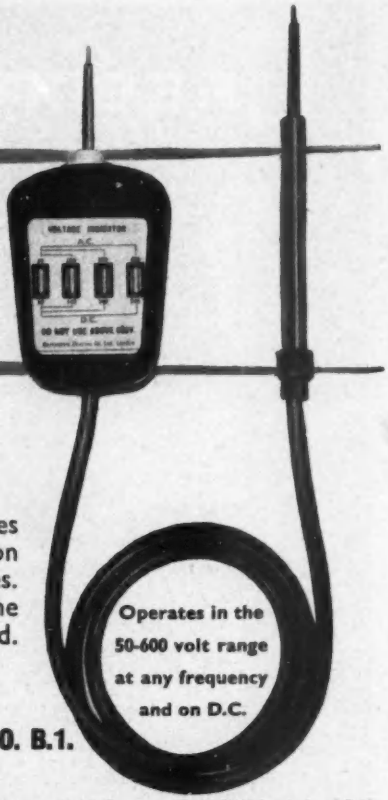

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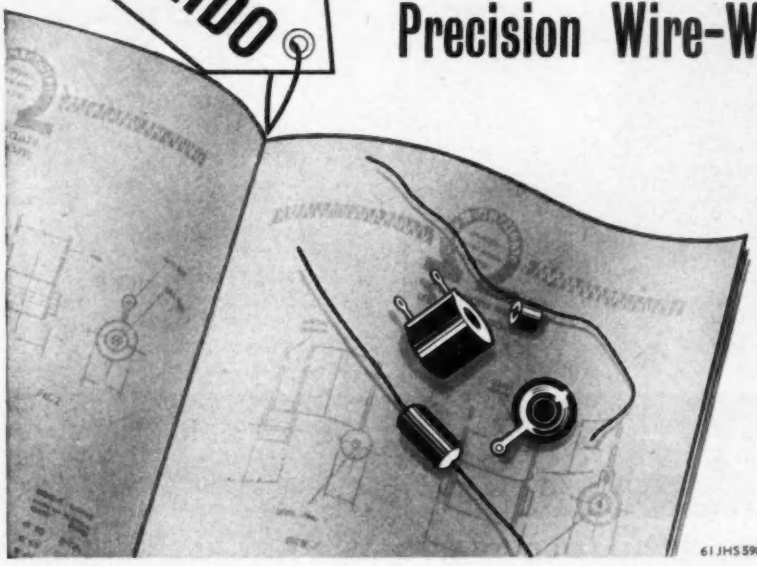

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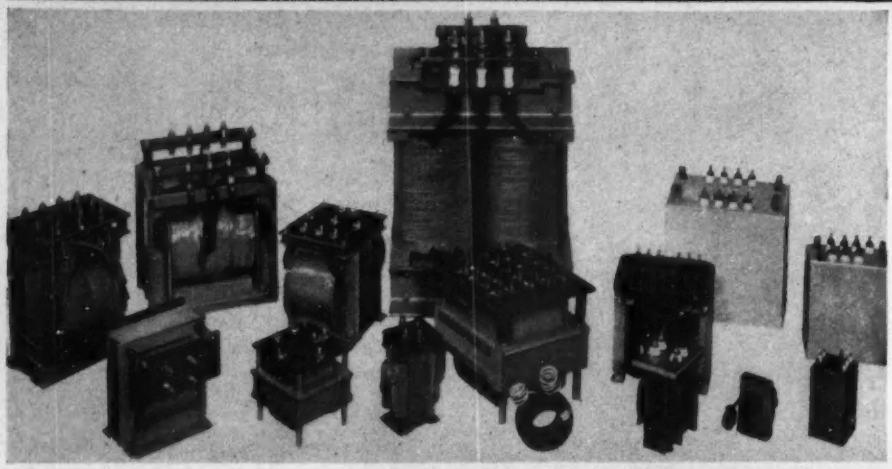

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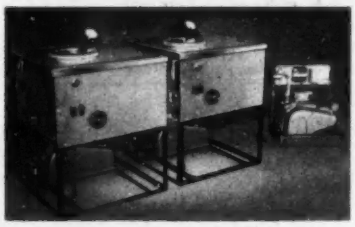

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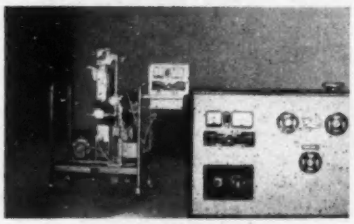

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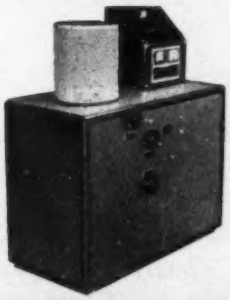

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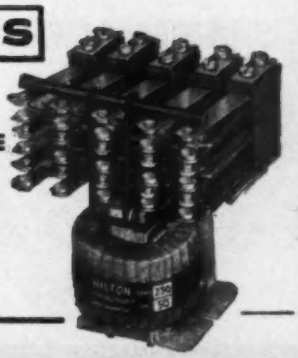

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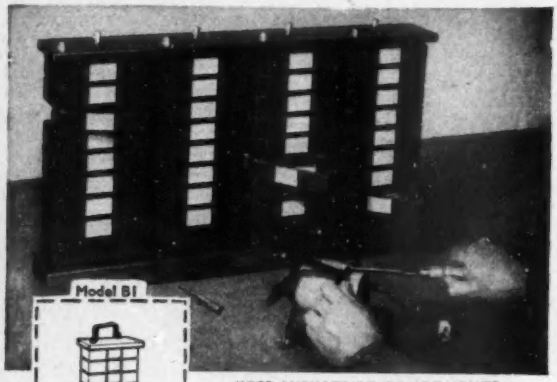
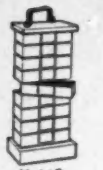
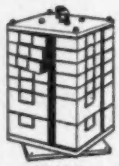


Model B1



Model C



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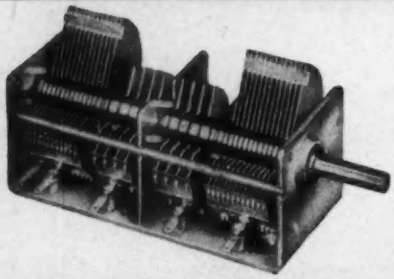

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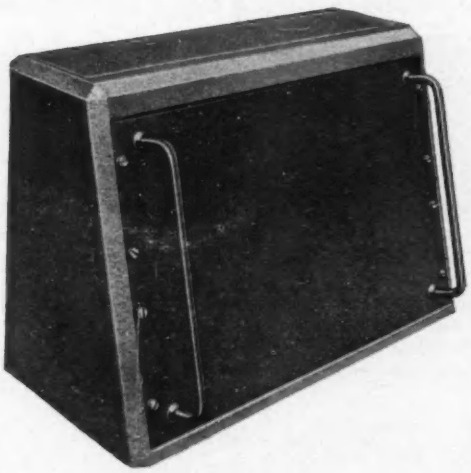

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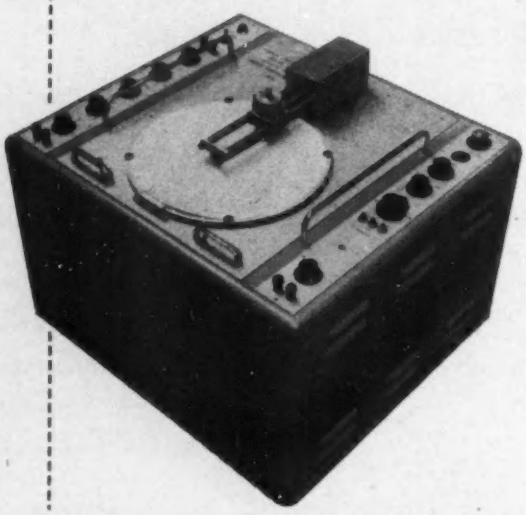

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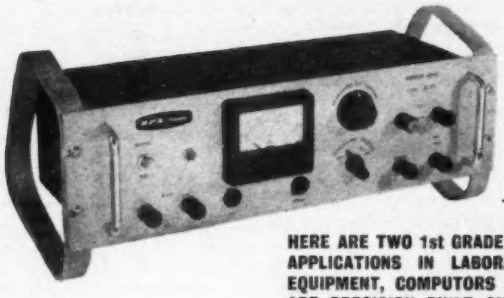

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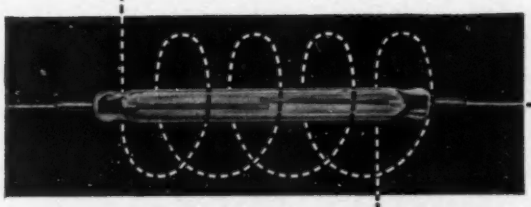

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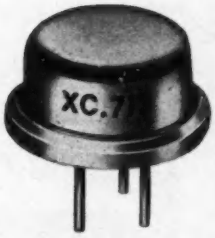

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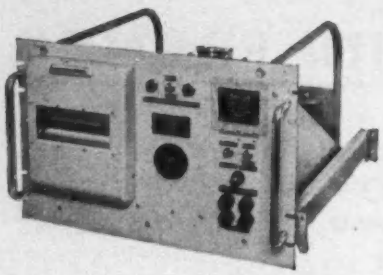

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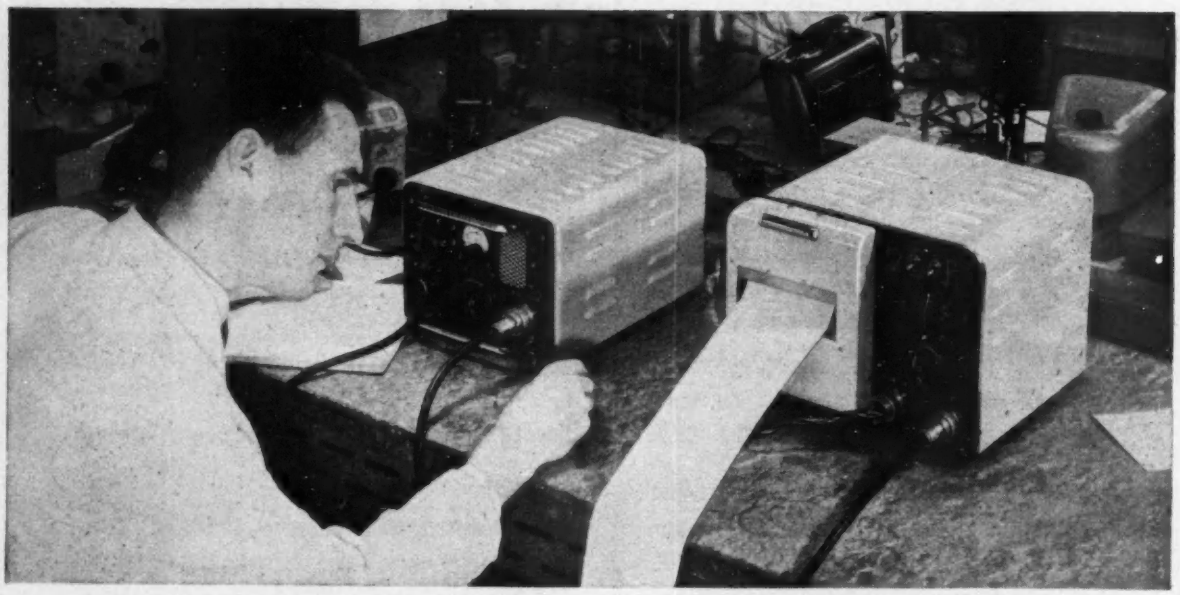

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INDEX TO ADVERTISERS

A

A.P.T. Electronic Industries Ltd. 90
Adcola Products Ltd. 154
Advance Components Ltd. 19, 99 105
Aircraft Marine Products (Gt. Britain) Ltd. .. 129
Airmec Ltd. 40, 204
Alkan, M. L., Ltd. 89
Allied Electronics Ltd. 154
Alma Components Ltd. 7
Ampex International 139, 141
Anders Electronics Ltd. 180
Ardente Acoustic Laboratories Ltd. 175
Armstrong Whitworth, Sir W. G. Aircraft Co. Ltd. 203
Ashburton Resistance Co. Ltd. 180
Associated Electrical Industries Ltd. Cover ii, 11, 101, 111, 113, 124, 175, 199, 203
Atkins, Robertson & Whiteford Ltd. 176
Austinlite (Stone-Chance Ltd.) 22

B

B. & K. Laboratories Ltd. 5, 159
B & R Relays Ltd. 44
B.I.P. Chemicals Ltd. 84
Barr & Stroud Ltd. 177
Belix Co. Ltd. 116
Belling & Lee Ltd. 74
Bendix-Ericsson (U.K.) 64, 118
Berliner Ausstellungen 181
Berna Industries Ltd. 181
Berry's Radio 176
Best Products Ltd. 179
Bir-Vac Ltd. 191
Birch, H. A., & Co. Ltd. 76
Birmingham Specialities Ltd. 174
Blackburn Electronics Ltd. 57
Boulton Paul Aircraft Ltd. 195
Bolton, Thomas & Sons Ltd. 183
Brandauer, C. & Co. Ltd. 182
Brandenburg Ltd. 122, 123
Brimar Ltd. 41, 201
Britec Ltd. 177
British Electric Resistance Co Ltd. 181
British Insulated Callender's Cables Ltd. .. 96
British Manufacture & Research Co. Ltd. .. 203
British Paints Ltd. 28
Brown, N. C., Ltd. 162
Broxlea Products Ltd. 172
Brush Crystal Co. Ltd. 137

C

Cannon Electric International Inc. 128
Carr Fastener Ltd. 49
Carter Gears Ltd. 207
Cawkell Ltd. 69
Chapman & Hall Ltd. 181
Chilton Electric Products Ltd. 75
Cinetra Mfg. Co. Ltd. 188
Cole, R. H., Ltd. 190
Colvern Ltd. 135
Co-ordinators Service (Engineering) Ltd. .. 166
Continental Connectors Ltd. 20
Crompton Parkinson Ltd. 157
Crosfield, J. F., Ltd. 202
Crosland, William, Ltd. 178

D

Datum Metal Products Ltd. 193
Darwins Ltd. 185
Davis, Jack (Relays) Ltd. 168
Derritron Electronics Group 146
Dobbie McInnes Ltd. 150
Dowding & Doll Ltd. 6
Dynatron Radio Ltd. 148

E

Elgar Trading Ltd. 179
Electro Methods Ltd. 147
Elliott Brothers (London) Ltd. 10
Engelhard Industries Ltd. 184
English Electric Co. Ltd. 132, 204
English Electric Valve Co. Ltd. .. 103, 201
Epsylon Industries Ltd. 108
Evans, Frederick W., Ltd. 179
Evershed & Vignoles Ltd. 102

F

Farnell Instruments Ltd. 154, 194
Ferranti Ltd. 110, 198, 200, 202
Fibreglass Ltd. 2
Fielden Electronics Ltd. 187
Formica Ltd. 15
Fortiphone Ltd. 162
Fry's Metal Foundries Ltd. .. .. Cover iv

G

Gabriel Mfg. Co. Ltd. 140
Gardner, Henry, Ltd. 3
Gardners Radio Ltd. 174
General Electric Co. Ltd. 109, 125, 127, 151, 200, 203
Goodmans Industries Ltd. 66
Greenpar Engineering Ltd. 187
Gresham Lion Group Ltd. 155
Guyson Industrial Equipment Ltd. 152

H

Haddon Transformers Ltd. 17
Hatfield Instruments Ltd. 156
Henning, J. A., Ltd. 158
Hewlett Packard S.A. Geneva 161
Hilton Electric Co. Ltd. 191
Hitachi Ltd. 72
Hivac Ltd. 195
Hughes International Ltd. 81
Hunt, A. H. (Capacitors) Ltd. .. Cover iii
Hurnant Electronics Ltd. 51

I

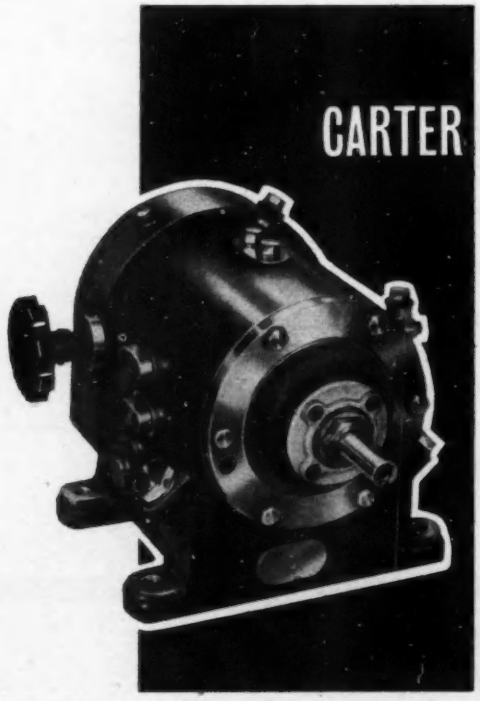
I.C.I. Ltd. 63, 106
Ilford Ltd. 67
Imhof, Alfred, Ltd. 45
Industrial & Commercial Finance Corpn. .. 208
Insuloid Manufacturing Co. Ltd. .. 160, 184
International Computers & Tabulators Ltd. .. 26
International Rectifier Co. (Gt. Britain) Ltd. .. 126
Ionic Plating Co. Ltd. 13

J

Jackson Brothers Ltd. 192
Johnson Matthey & Co. Ltd. 12

K

Kappa Electronics 200
Keith Blackman Ltd. 150
Kent Alloys Ltd. 173
Ketay Ltd. 112
Knight, Frank & Rutley Ltd. 204
Knitmesh Ltd. 168



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INDEX TO ADVERTISERS *(continued from previous page)*

L

Langham Thompson, J., Ltd. 77
Levell Electronics Ltd. 164
Lexor Electronics Ltd. 181
Lintott, H. E., Ltd. 14
Linvar Ltd. 186
Lyons, Claude, Ltd. 114

M

M.O. Valve Co. Ltd. 73
McMurdo Instrument Co. Ltd. 189
Mackie, W. & Co. Ltd. 136
Marconi Instruments Ltd. 107
Markem Machine Agency 167
Martindale Electric Co. Ltd. .. 182, 188
Measuring Instruments (Pullin) Ltd. 42
Mervyn Instruments Ltd. 163
Mesucora 171
Metal Box Co. Ltd. 204
Micanite & Insulators Ltd. 37
Midland & Lowmoor Iron & Steel Co. Ltd. .. 55
Midland Silicones Ltd. 144
Mills & Rockley Electronics Ltd. 140
Miltoid Sales Division (BX Plastics Ltd.) .. 152
Ministry of Labour 170
Mullard Ltd. 36, 38, 39, 58, 60, 61, 79, 85, 88, 145
Mullard Radio Valve Co. Ltd. 204
Murex Ltd. 168
Muirhead & Co. Ltd. 8

N

N.G.N. Electrical Ltd. 183
Nagard Ltd. 131
New Electronic Products Ltd. 205
Newmarket Transistors Ltd. 45
Nippon Electric Company Ltd. 29

O

Oxley Developments Ltd. 68

P

Page Engineering (Sunbury-on-Thames) Ltd. 178
Painton & Co. Ltd. 70
Panorama Radio Company 194
Phillips Control (Gt. Britain) Ltd. 176
Plannair Ltd. 169
Plessey Ltd. 24, 59, 82, 202, 204
Preformations Ltd. 97
Pye, W. G., & Co. Ltd. 78

R

Racal Instruments Ltd. 165
Radio Resistor Co. Ltd. 4
Radiometer 55
Radiospares Ltd. 134
Rank Cintel Ltd. 98
Ratcliffe, F. S. (Rochdale) Ltd. 115
Rawplug Co. Ltd. 21
Reliance Gear Co. Ltd. 160
Research & Control Instruments Ltd. .. 186
Rivlin Instruments Ltd. 9
Rollet, H. & Co. Ltd. 50

S

Salford Electrical Instruments Ltd. 141, 148, 170, 185
Salter, George & Co. Ltd. 43
Sanders, W. H. (Electronics) Ltd. 34
Saxonia Electrical Wire Co. Ltd. 179
Scott, James & Co. (Electronic Engineering) Ltd. 133
Servo Consultants Ltd. 194
Servomex Controls Ltd. 86, 87
Shardlow Micrometers Ltd. 192
Short Brothers & Harland Ltd. 48
Sifam Electrical Instruments Co. Ltd. .. 52
Sivers Lab. 159
Smallbone & Sons (Service Station) Ltd. .. 192
Smart & Brown Ltd. 177
Smiths Clocks & Watches Ltd. 166
Smith, John, Ltd. 174
Solartron Electronic Group Ltd. .. 62, 94, 95
South London Electrical Equipment Co. Ltd. 158
Standard Telephones & Cables Ltd. Cover i, 23, 25, 27, 117, 119, 121, 162
Steatite & Porcelain Products Ltd. 54
Stevenage Relays Ltd. 188
Stewart Transformers Ltd. 152
Stone-Chance Ltd. (Flamemaster) 156
Sterne, L., & Co. Ltd. 65
Superflexit Ltd. 91
Surrey Steel Components Ltd. 175

T

Telephone Mfg. Co. Ltd. 53, 100
Telequipment Ltd. 138
Tessier, V., Ltd. 194
Texas Instruments Ltd. 33, 35
Thorn Electrical Industries Ltd. 71, 153
Tokyo Shibaura Electric Co. Ltd. 30
Transradio Ltd. 142, 143
Transitron Electronic Ltd. 92, 93
Turner Bros. Asbestos Co. Ltd. 104
Turner, Ernest, Electrical Instruments Ltd. .. 120
Tyer & Co. Ltd. 160

U

U.K.A.E.A. 202
Ultra Electronics Ltd. 201
United Components Ltd. 205

V

Vactite Wire Ltd. 164
Vactric (Control Equipment) Ltd. 47
Vacwell Engineering Co. Ltd. 149
Venner Electronics Ltd. 32
Vero Precision Engineering Ltd. 18

W

Walters, Austin, Ltd. 190
Wayne-Kerr Laboratories Ltd. 80
Webb's Radio 176
Webber, R. A., Ltd. 177
Welwyn Tool Co. 170
Westinghouse Brake & Signal Co. Ltd. .. 130
Westrex Co. Ltd. 31
Whiteley Electrical Radio Co. Ltd. 3
Wilkinson, James & Sons Ltd. 83
Wilkinson, L. (Croydon) Ltd. 179
Wingrove & Rogers Ltd. 16
Wright & Marvin Ltd. 174

Z

Zenith Electric Co. Ltd. 189

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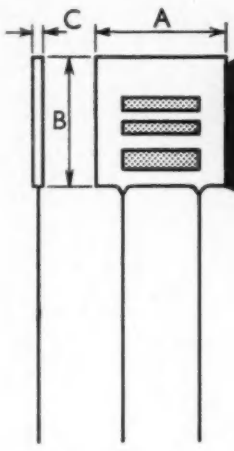
208/68



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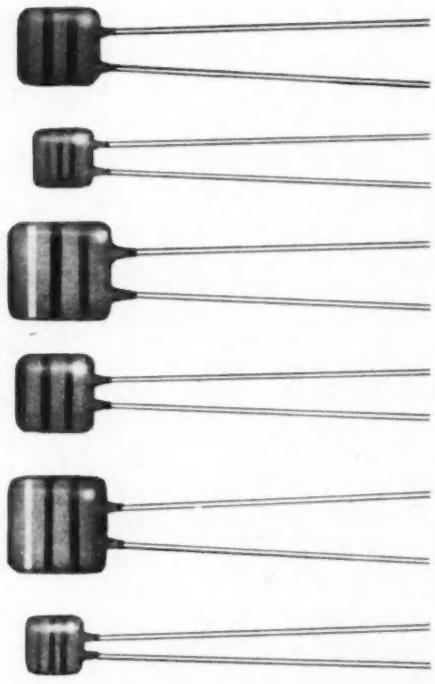

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